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SURFACE-DUCT SONAR MEASUREMENTS (SUDS I - 1972) PROPAGATION LOS--ETC(U)

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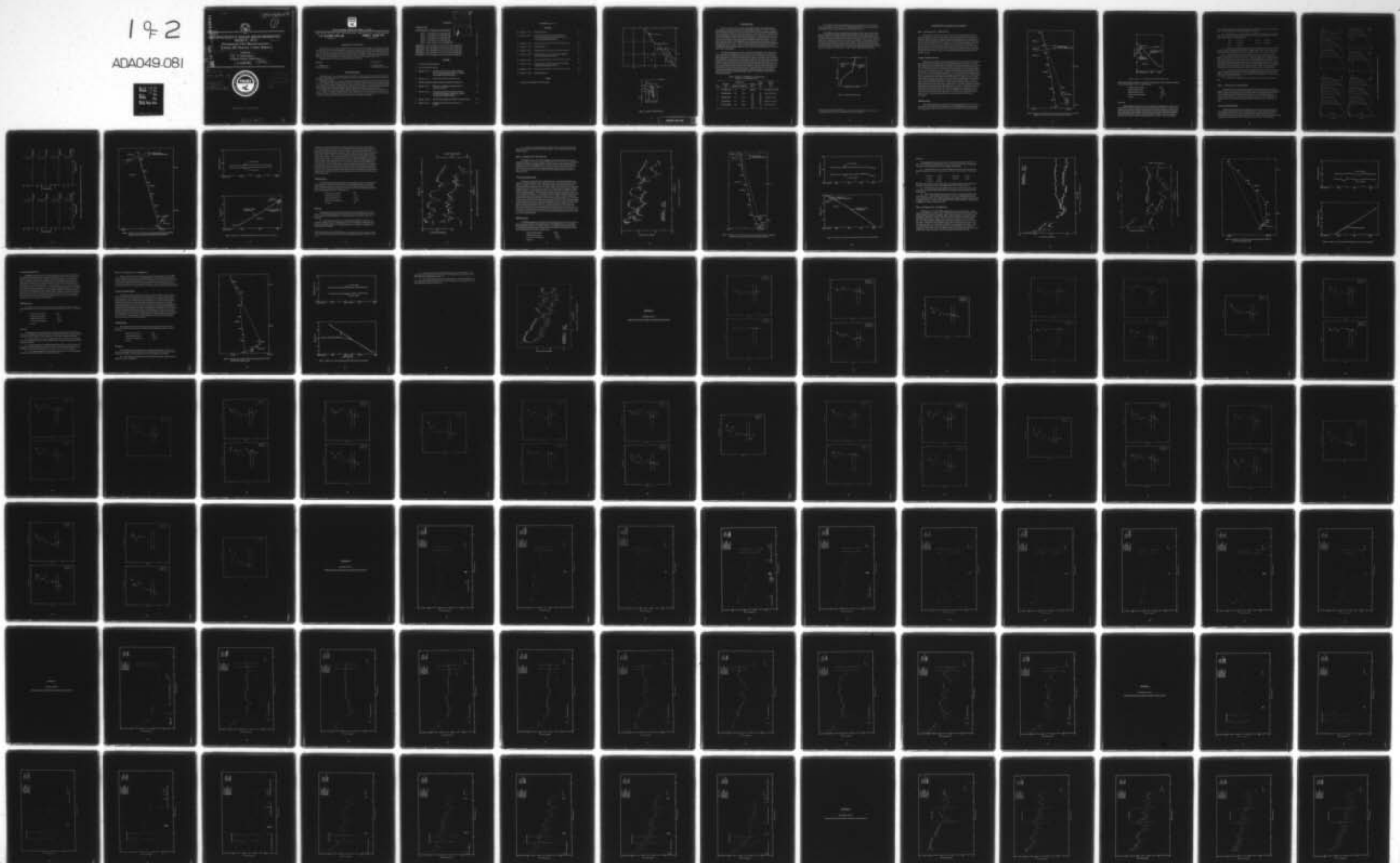

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SURFACE-DUCT SONAR MEASUREMENTS (SUDS I - 1972)

Propagation Loss Measurements. Volume IV: Station 3 Data Report.

edited by

(10) E. R. Anderson

Undersea Sciences Department

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AN ACTIVITY OF THE NAVAL MATERIAL COMMAND

R. B. GILCHRIST, CAPT, USN
Commander

HOWARD L. BLOOD, PhD
Technical Director

ADMINISTRATIVE INFORMATION

During February 1972 the Naval Undersea Center conducted a series of 18 propagation loss experiments in three deep-water areas off the coast of California. These experiments are known as the SUrface Duct Sonar Measurements (SUDS I – 1972). This work was originally supported by the then Naval Ships Systems Command, Sonar Technology Division, PMS-302-4 and partly supported by the Office of Naval Research, code 102-OSC. The preparation of this report began in April 1973 under the sponsorship of the Naval Sea Systems Command, code 06H1-4, problem SF 52-552-602, task 19344. This report covers work from March 1971 to February 1976 and was approved for publication in April 1976.

Technical reviewers for this report were M. A. Pedersen and R. F. Hosmer.

Released by

H. E. MORRIS, Head
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Under authority of

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ACKNOWLEDGEMENTS

The SUDS I program was a coordinated and cooperative effort involving personnel from the Undersea Sciences and the Undersea Surveillance Departments. The program was basically an Acoustic Propagation Division project developed by H. P. Bucker and H. S. Aurand.

The Principal Investigator was J. Cummins. H.P. Bucker was the Senior Scientist for the CW-pulse measurements and D. L. Keir the Senior Scientist for the explosive measurements. Additional contributions were made to experiment planning by J. R. Lovett and J. D. Pugh. Preliminary analysis of acoustical data was done by H. P. Bucker and H. E. Morris. Assisting in the preliminary data reduction and analysis of the acoustic data was J. L. Thompson, an exchange scientist from RANRL, Sidney, Australia, and R. W. Townsen. Preliminary analysis of the environmental data was done by K. W. Nelson.

H. P. Bucker was the Scientist-in-Charge aboard the *DeSteiguer*, D. G. Good was Scientist-in-Charge aboard the *Lee*, and P. A. Hanson was Scientist-in-Charge aboard the *Cape*. Assisting with the acoustic measurements at sea were: T. E. Stixrud, C. R. Lisle, N. J. Martini, D. White, and R. F. Hosmer. The assistance of the officers and men of the *DeSteiguer*, *Lee*, and *Cape* in making the propagation loss measurements program successful is acknowledged.

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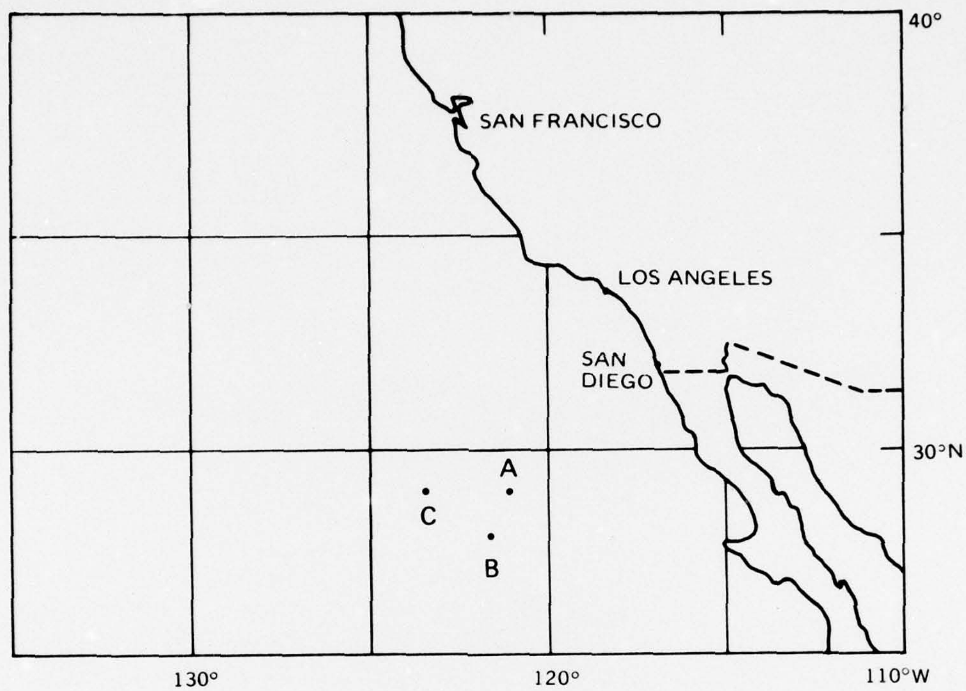


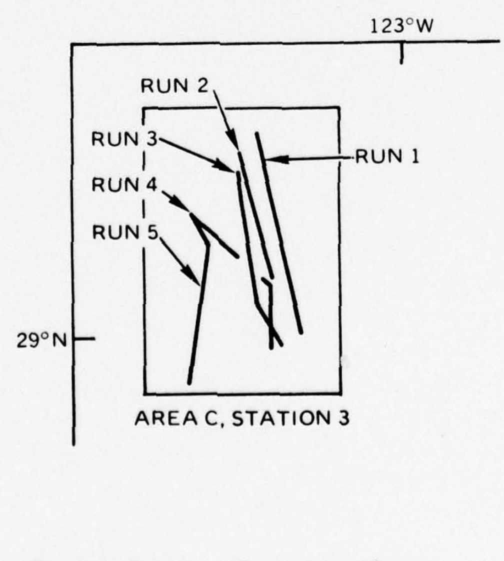


Figure 1. Location of experimental areas.

INTRODUCTION

This is the fourth in a series of five volumes describing the near-surface acoustic propagation loss measurements made during the SUDS I experiments. Volume I describes the experimental procedures, discusses the instrumentation used in making the propagation loss measurements, and the data reduction procedures. This volume (IV) is a detailed report of the propagation loss measurements made during station 3, in which five acoustic experiments were completed. Figure 1 shows the track of the source ship during these runs. Also shown are the locations of sound-speed profile boundaries crossed during runs 1, 2, and 3. Source ship's speed was 3 knots during all runs. CW pulsed sources were used on runs 2-5 and explosive sources on run 1. Table 1 summarizes information pertinent to the individual propagation loss runs. Listed for each run are the beginning and ending dates and times, minimum and maximum range between the source and receiver ships, frequencies used, and source and receiver depths.

The detailed propagation loss data are contained in Appendices A-E. These appendices contain plots of propagation loss as a function of acoustic range for each frequency and receiver depth. CW pulsed sources were used on runs 2-5. The plots for these runs are the propagation loss for each received CW pulse as a function of acoustic range. At the bottom of each plot remarks pertinent to that plot are indicated. The maximum acoustic range is indicated by the vertical arrow (↓) and individual noise level determinations by the symbol (∿). In addition, arrivals missing because of down periods when the recorder paper was being changed, periods when the source was inoperative, and periods when the arrivals, or most of the arrivals, were below noise are shown. Explosive sources were used during run 1. On these plots the noise-limited measurements are plotted as triangles. These measurements represent minimum possible propagation losses. Non-noise-limited measurements are plotted as squares.

Table 1. Summary of Propagation Loss Experiments
Station 3, 19-20 February 1972

Run	Date/time LST	Range, kyd Minimum	Range, kyd Maximum	Frequency, kHz	Source depth, m	Receiver depth, m
1	19/1500-2130	5.2	31.1	explosive	18	6/34/69/112/173/38
2	20/0105-0630	3.9	33.6	1.5	42	6/37/73/119/182
				2.5	42	
3	20/0658-1418	0.1	37.5	0.4	42	6/34/69/112/173
				1.0	42	
4	20/1530-2052	0.1	33.3	3.5	44	6/36/72/117/180
				5.0	47	
5	20/2131-0400	2.9	36.0	3.5	6	6/35/71/115/177
				5.0	9	

The remainder of this report discusses for each propagation loss run the average sound-speed profiles, average values for the AMOS parameters, and the major propagation loss features based on a visual comparison of propagation loss plots.

The AMOS near-surface propagation loss prediction model requires single average values of isothermal layer depth, depressed channel depth, sea state, and sea surface temperature as inputs.* The isothermal layer depth is defined as the depth below the surface at which the temperature gradient from the surface is greater than −0.3°F/100 ft. Because of the effect of pressure, this results in a surface sound channel. The depressed channel is formed by an isothermal layer within the water column. This latter vertical temperature structure results in a sound-speed minimum near the top of the isothermal layer because of the effect of pressure on sound speed. The width of the depressed channel is approximately equal to the depth of the channel axis.* Figure 2 aids in defining these parameters.

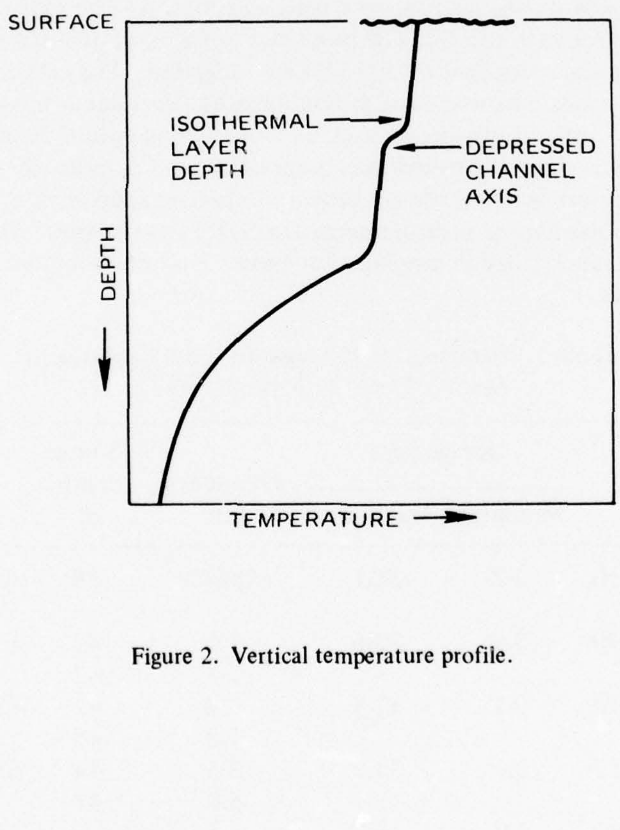


Figure 2. Vertical temperature profile.

**Underwater Sound Laboratory Report 255A*, Report on the Status of Project AMOS (Acoustic, Meteorological, and Oceanographic Survey), *by H. W. Marsh and M. Shulkin, March 1955 (revised May 1967).*

ENVIRONMENTAL SUMMARY AND COMMENTS

RUN 1 19 February 1972, 1500-2130 LST

During this run explosive sources were used to measure propagation losses over acoustic ranges from 5.2 to 31.1 kyd. Figure 3 shows the track of the source and receiver ships, the 1500 and 2130 LST propagation paths, and the locations of two sound-speed profile boundaries which were crossed at about 1610 and 1640 LST at acoustic ranges from the receivers of 25.0 and 23.6 kyd. For ranges out to 23.6 kyd the propagation was in the profile 3 volume, and from 23.6 to 25.0 kyd it was in the profile 2 and 3 volumes. For ranges greater than 25.0 kyd, all three profile volumes were involved. Figure 4 contains a plot of range from receivers, derived from 21 travel-time measurements, versus time of day. In Fig. 4 the range from the receivers of the sound-speed profile boundaries is shown as a function of time.

Average Sound-Speed Profiles

Individual sound-speed profiles suggested that the source ship crossed a sound-speed profile transition water volume between 1610 and 1640 LST over a distance of 2.2 kyd. The change was further confirmed by the thermistor chain measurements from 79 to 130 m. These measurements showed a temperature change of from 0.5 to 1.0°C between 90 and 124 m. This increase resulted in the elimination of the depressed channel present during the first part of the acoustic run. Figure 5 contains plots of the three average sound-speed profiles. Profile 1 contains two depressed channels – a 75-m channel with the minimum sound speed at 17 m and a 33-m channel with the minimum sound speed at 110 m. Profile 3 has a 101-m depressed channel with minimum sound speed at 28 m. Profile 2 is not an average profile in the same sense that profiles 1 and 3 are, since the profile shapes in the transition water volume are gradually changing from profile 1 shape to profile 3 shape. In Fig. 5 the source and receiver depths are also shown. During this run both the source and receiver ships reported winds of less than 5 knots, ripples, and 3- to 6-ft swell. Sea-surface roughness measurements were obtained by the Waverider buoy from 1615 to 2130 LST. No measurements were obtained from 1500 to 1615 LST. Spectral analysis of the Waverider buoy measurements revealed that most of the sea-surface roughness was contained in a 12.0- to 15.0-sec wave-period band of swell. Receivers 1, 2, and 3 were in the depressed channel, receiver 4 was 11 m below the depressed channel, and receiver 5 was in the main thermocline.

AMOS Parameters

The AMOS propagation loss prediction model assumes that sources and receivers are in the same water volume, in which single values of the AMOS parameters are applicable. This assumption is valid out to a range of 23.6 kyd. The number of observations and the

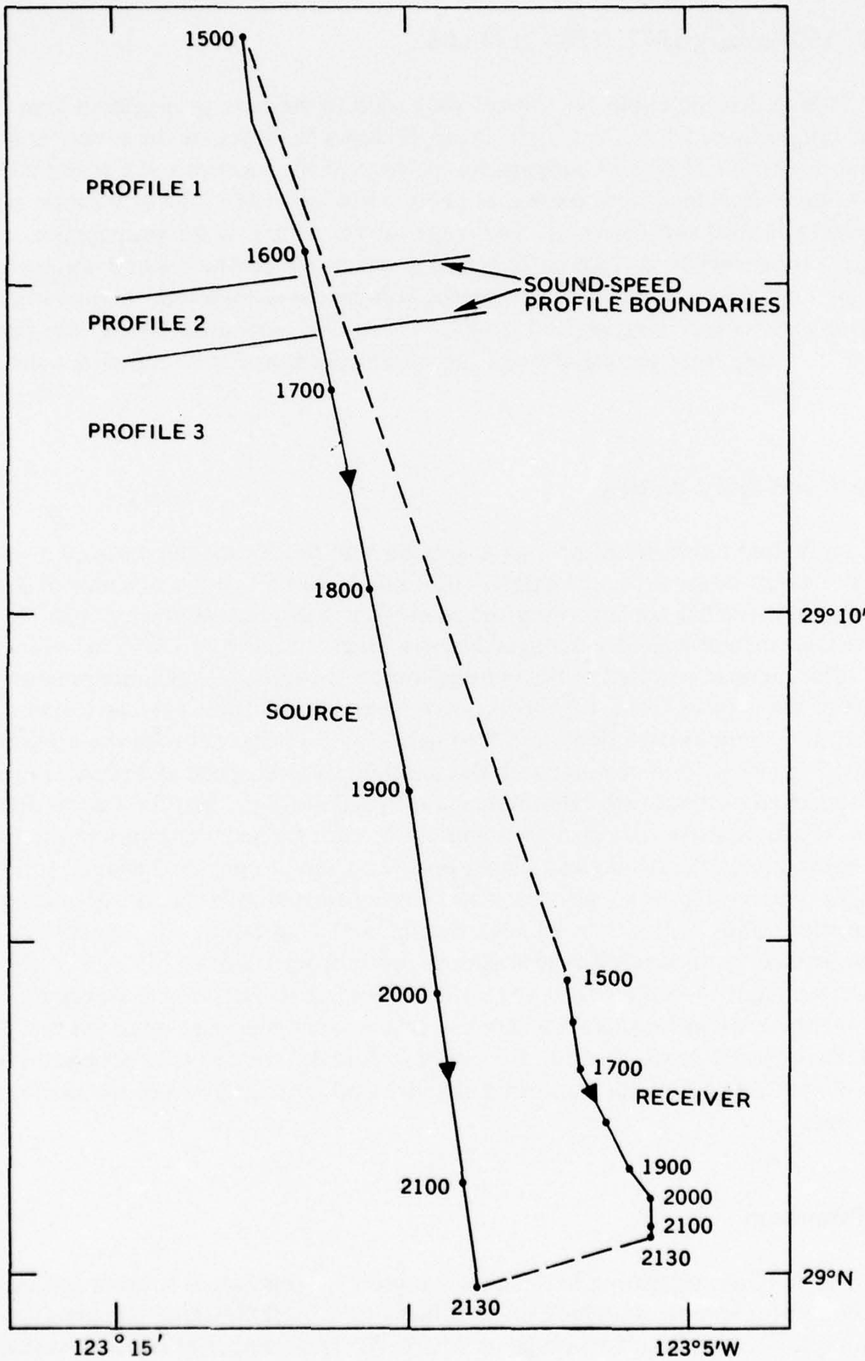


Figure 3. Station 3, run 1. Tracks of source and receiver ships, 1500 LST and 2130 LST. propagation paths, and location of sound-speed profile boundaries.

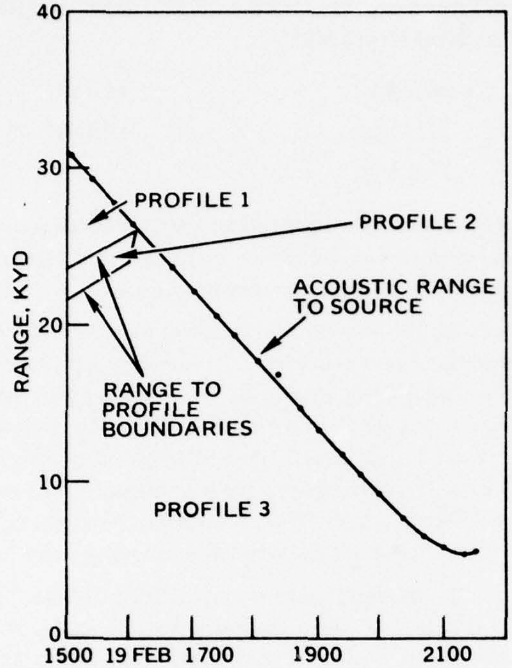


Figure 4. Station 3, run 1 Ranges from receiver versus time of day.

average values of these parameters, derived from the thermistor chain temperature measurements, and applicable to the run 1 experiments are:

number of observations	1755
isothermal layer depth	0 ft
depressed channel axis	112 ft
surface water temperature	59.2°C
sea state	0-1

Discussion

The propagation loss measurements are summarized in Appendix A. The data were analyzed with 1/3-octave filters centered at eight frequencies from 0.4 to 10.0 kHz. Data points not noise limited are plotted as squares on the explosive propagation loss plots and noise-limited data as open triangles. Noise-limited points represent minimum propagation loss at the plotted range. On these plots the vertical lines indicate the acoustic range at which the source ship crossed the sound-speed profile boundaries. The source depth of

18 m is 10 m above the 28-m depressed channel axis, and the 36-m receiver is 8 m below the axis. A visual comparison of these plots suggests the following:

- At all frequencies, except the highest (10.0 kHz), shot arrivals were recorded on all receivers out to the maximum acoustic range of 31.1 kyd. At 10.0 kHz the maximum range recorded for each receiver depth was:

6 m	26.7 kyd	112 m	27.3 kyd
36 m	27.3 kyd	173 m	23.2 kyd
69 m	19.6 kyd		

- In general, the lowest propagation loss was recorded on the 36-m receiver, with the next lowest recorded on the 69-m receiver. Both of these receivers were located in the depressed channel. The greatest losses were recorded on the 6-, 112-, and 173-m receivers.

- At all frequencies the lowest propagation losses were recorded at the 36-m receiver and the greatest at the 173-m receiver. Figure 6 is a plot of the propagation loss difference between the 36- and 173-m receivers. The propagation loss recorded on the 36-m receiver is less than that recorded on the 173-m receiver if the difference is positive. The vertical lines indicate the acoustic ranges of the sound-speed profile boundaries. For ranges from about 15.0 to 28.0 kyd, the differences are a nominal 20 dB or greater. At ranges less than about 15.0 kyd, the differences are smaller and more variable. For all frequencies, except 0.4 and 1.6 kHz, the differences decrease for ranges greater than about 28 kyd.

- At 6, 69, and 112 m there were no consistent differences between the seven frequencies from 0.40 and 5.0 kHz. At 34 m the propagation loss is largest at 5.0 and 10.0 kHz for ranges greater than about 17.0 kyd, with little consistent difference between the six frequencies from 0.40 to 3.15 kHz.

- For all receiver depths the greatest propagation losses were recorded at 10.0 kHz.

RUN 2 – 20 February 1972, 0105-0630 LST

During this run, 1.5- and 2.5-kHz propagation losses were measured over acoustic ranges from 3.9 to 33.6 kyd. Figure 7 shows the tracks of the source and receiver ships, the 0105 and 0630 LST propagation paths, and the location of two sound-speed profile boundaries crossed during the run. Figure 8 contains plots of source level and ranges from receivers, derived from 12 travel-time measurements, versus time of day. In Figure 8, the range from the receivers to the sound-speed profile boundaries is shown as a function of time.

Average Sound-Speed Profiles

Individual sound-speed profiles suggested that the source ship recrossed the same sound-speed profile transition volume crossed during run 1 between 0605 and 0620 LST over a distance of about 1.4 kyd. The change was further confirmed by a plot of the thermistor chain temperature measurements from 79 to 130 m. These measurements showed a temperature change of from 0.5 to 1.0°C between 85 and 107 m. This decrease in

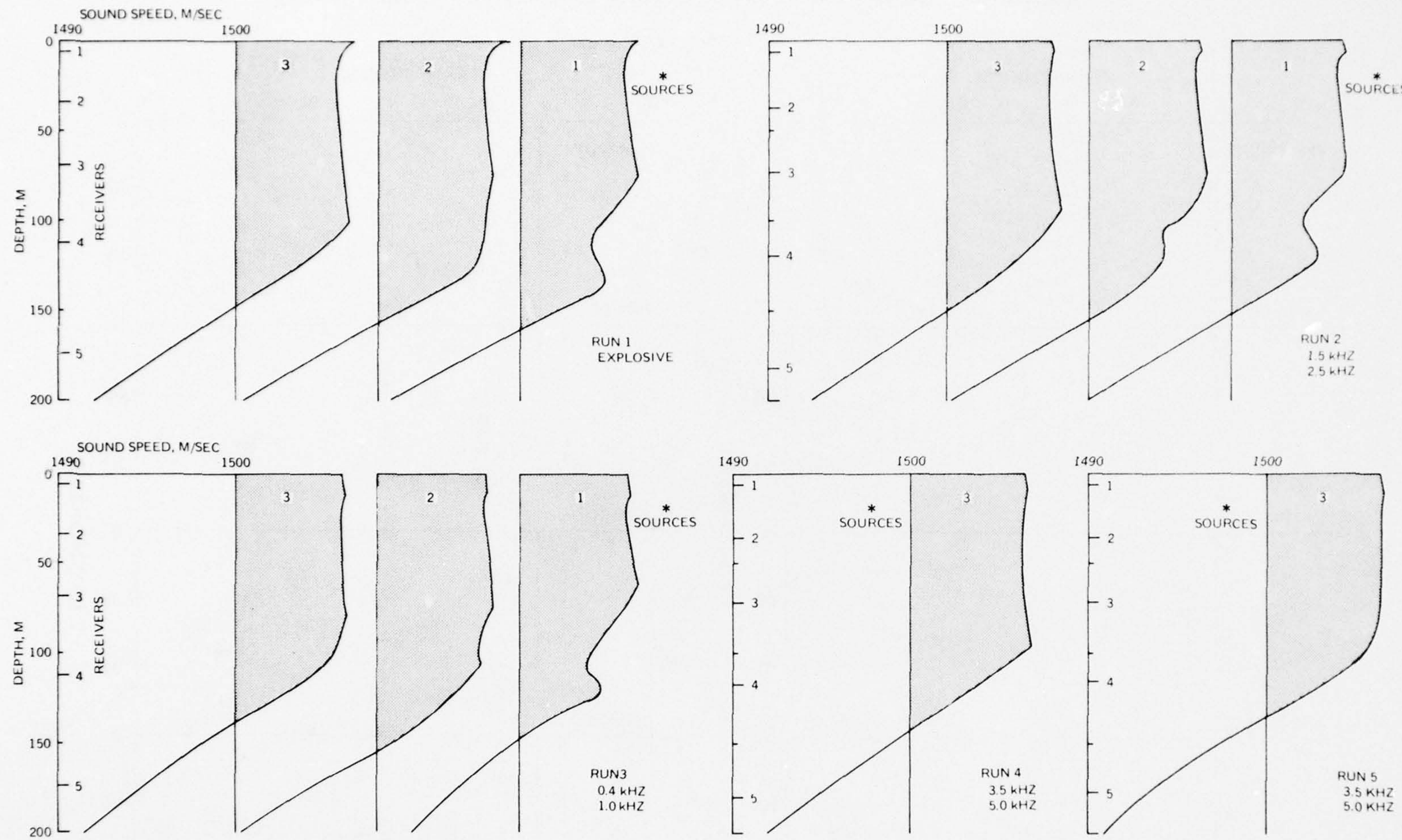


Figure 5. Average sound-speed profile summary for station 3 acoustic runs.

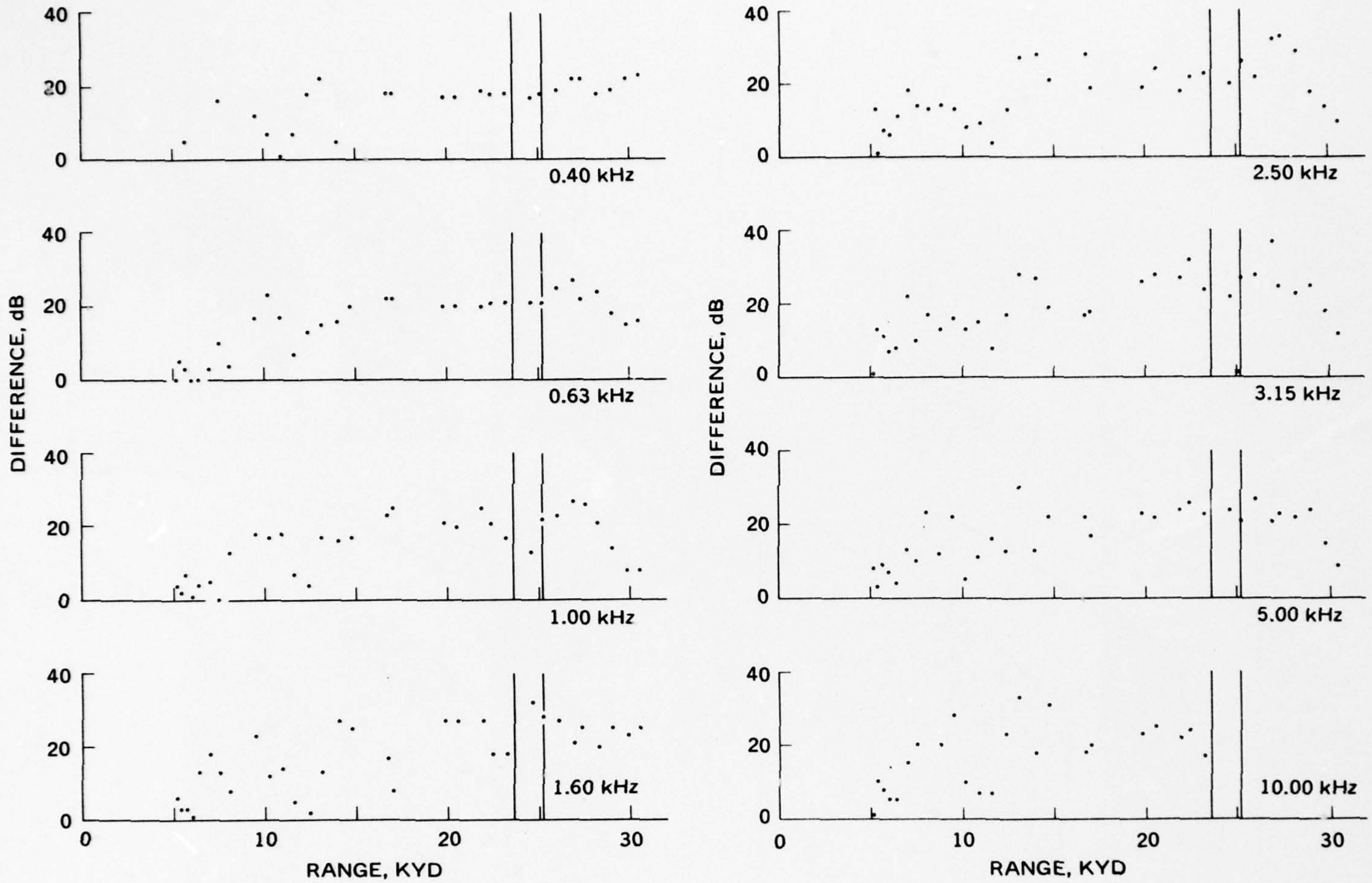


Figure 6. Station 3, run 1. Difference in propagation loss between 36-m and 173-m receivers.

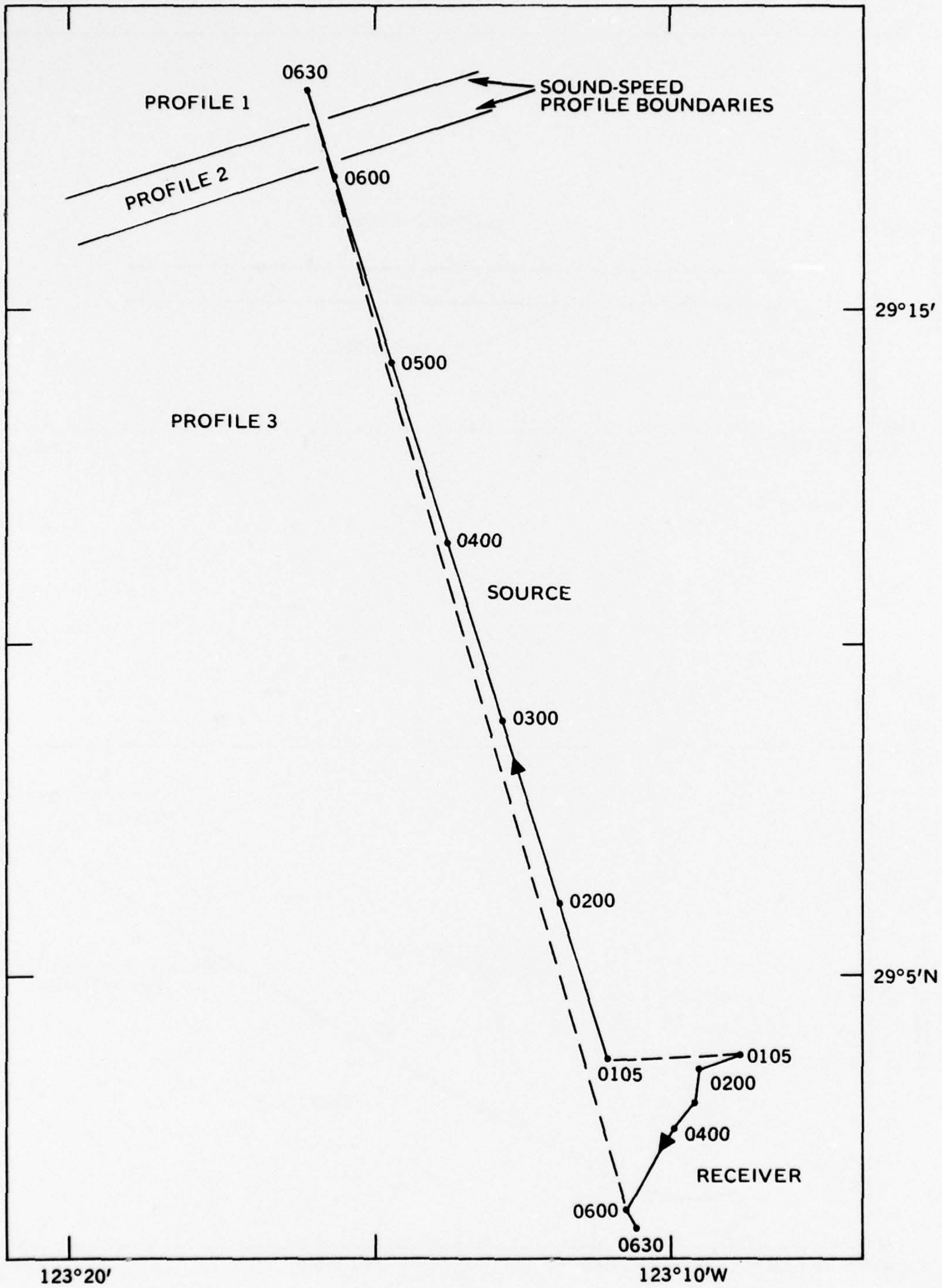
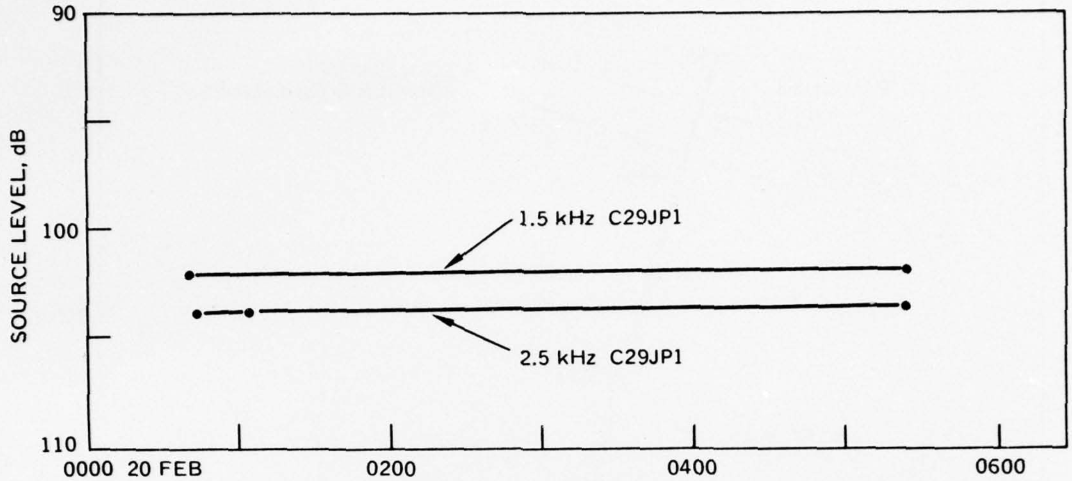


Figure 7. Station 3, run 2. Tracks of source and receiver ships, 0105 LST and 0630 LST propagation paths, and locations of sound-speed profile boundaries.



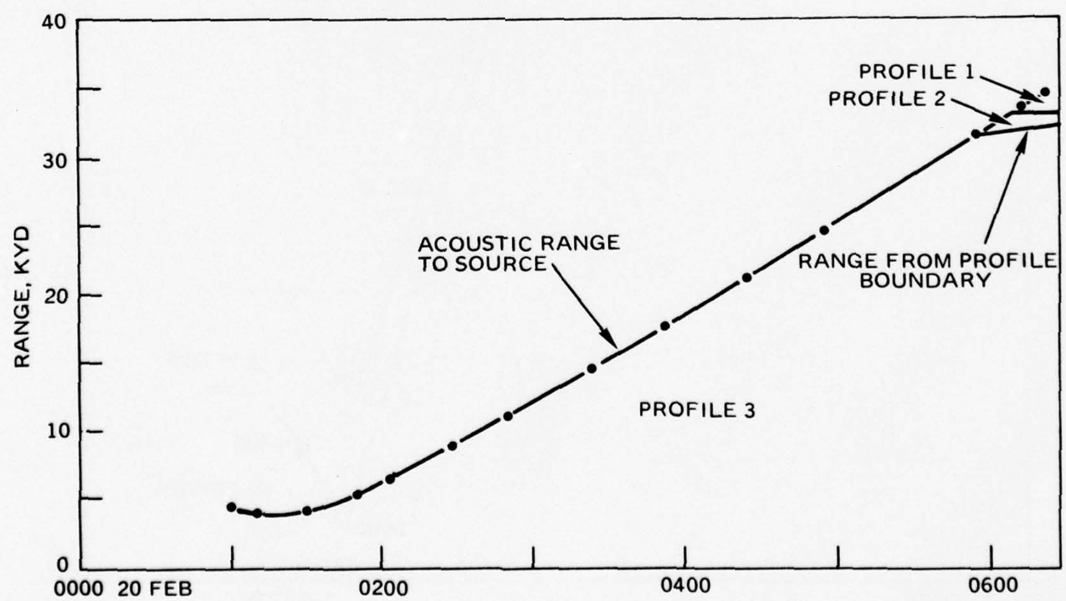


Figure 8. Station 3, run 2. Source level and range from receiver versus time of day (LST).

temperature resulted in the formation of a depressed channel. Figure 5 contains plots of the average sound-speed profiles. As a result of nighttime cooling of the surface waters, all average profiles show a 6-m surface channel. Profile 1 contains two depressed channels – a 50-m channel with the minimum sound speed at 20 m and a 20-m channel with the minimum sound speed at 101 m. Profile 3 has a 54-m depressed channel, with the minimum sound speed at 20 m. Profile 2 is not an average profile in the same sense that profiles 1 and 3 are, since the profile shapes in the transition water volume are gradually changing from profile 3 shape to profile 1 shape. During this run both the source and receiver ships reported winds less than 5 knots at the beginning of the run, increasing to about 10 knots at 0400 LST, waves less than 1 ft, and 3- to 4-ft swell. Sea-surface roughness measurements were obtained by the Waverider buoy for all but the first 5 min of the run. Spectral analysis of the Waverider buoy measurements revealed that most of the sea-surface roughness was contained in a 12.0- to 15.0-sec wave-period band of swell. Receiver 1 was at the same depth as the surface sound channel, receivers 2 and 3 were in the depressed channel, and receivers 4 and 5 were in the main thermocline.

AMOS Parameters

The AMOS propagation loss prediction model assumes that sources and receivers are in the same water volume, in which single values of the AMOS parameters are applicable. This assumption is valid out to a range of 31.4 kyd. The number of observations and the average values of these parameters, derived from the thermistor chain temperature measurements, and applicable to the run 2 experiment are:

number of observations	1809
isothermal layer depth	20 ft
depressed channel axis	112 ft
surface water temperature	59.2°F
sea state	0-3

Discussion

The propagation loss measurements are summarized in Appendix B. The vertical lines on the individual propagation loss plots indicate the acoustic range from the receivers of the sound-speed profile boundaries. A visual comparison of these plots suggests the following:

- The most pronounced feature is the regular modal patterns observed at all depths for both frequencies. As illustrated by Fig. 9,* the complexity of the pattern and the random variability is greater at the higher frequency (for clarity the propagation loss scales are offset by 20 dB).

**A maximum of four CW pulses were transmitted each minute. For simplification, all pulses received during each minute (i.e., 1, 2, 3, or 4) were averaged. These average values are plotted on all propagation loss plots used in the text of this report.*

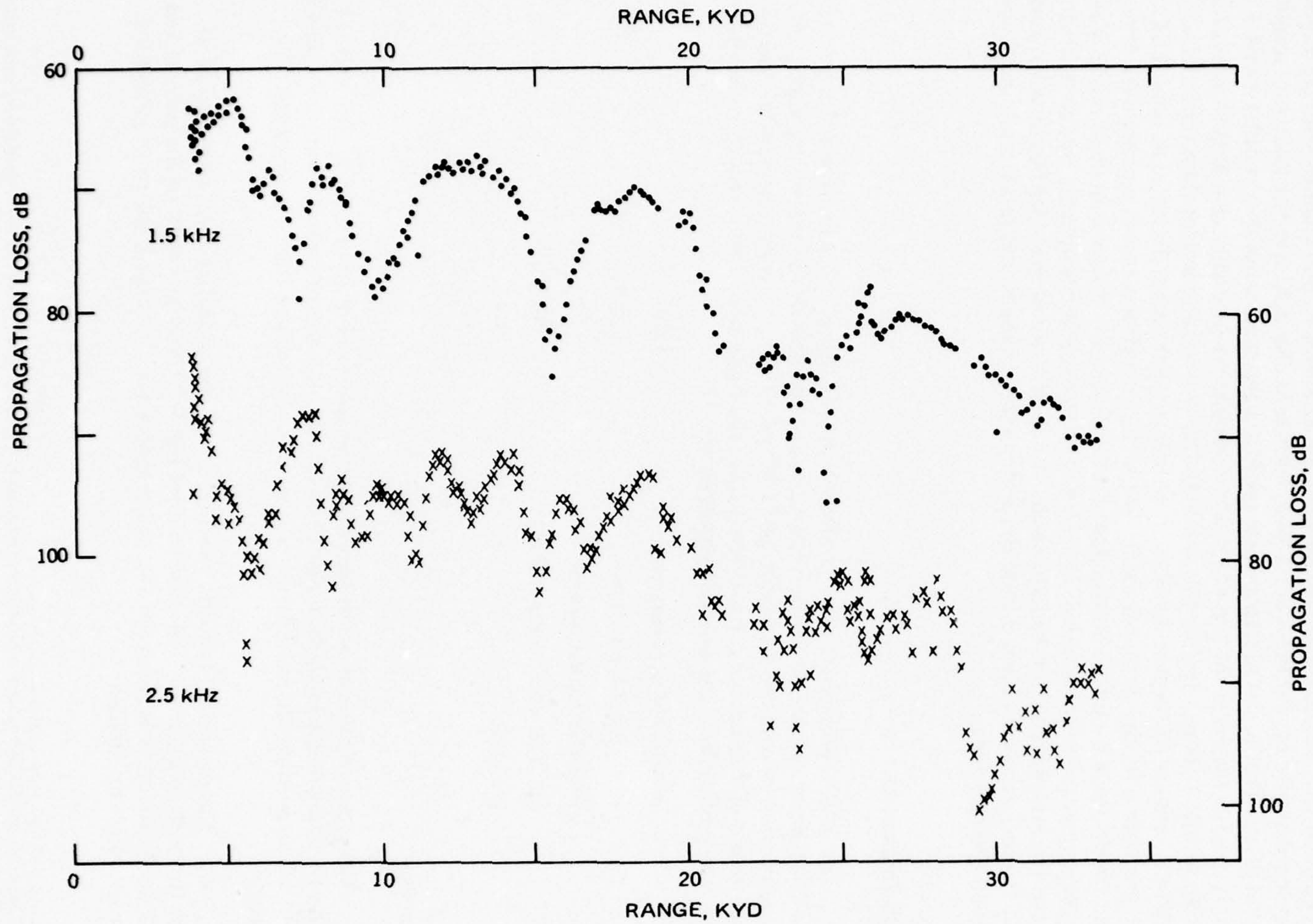


Figure 9. Station 3, run 2. Propagation loss for 42-m source and 37-m receiver.

- In general, the propagation loss is smallest for the receivers in the depressed channel and greatest for those in the main thermocline. This maximum difference is illustrated by Fig. 10.

RUN 3 20 February 1972, 0658-1418 LST

During this run 0.4- and 1.0-kHz propagation losses were measured over acoustic ranges from 100 yd to 37.5 kyd. Figure 11 shows the track of the source and receiver ships, the 0658 and 1400 LST propagation paths and the locations of two sound-speed profile boundaries that were crossed during the run. Figure 12 contains plots of source level and range from receivers, derived from 22 travel-time measurements, versus time of day. In Fig. 12 the range from the receivers to the sound-speed profile boundaries is shown as a function of time.

Average Sound-Speed Profiles

Individual sound-speed profiles suggested that the source ship recrossed the same sound-speed profile transition volume crossed during runs 1 and 2 between 0705 and 0730 LST over a distance of about 2.3 kyd. The change is further confirmed by a plot of the thermistor chain measurements from 79 to 130 m. These measurements show a temperature change of from 0.5 to 1.0°C between 85 and 107 m. This increase in temperature resulted in the elimination of a depressed channel present at the start of the run. Figure 5 is a plot of the sound-speed profiles. All three profiles contain 11-m surface channels. Profile 1 contains two depressed channels – a 20-m channel with the minimum sound speed at 20 m and a 22-m channel with the minimum sound speed at 105 m. Profile 3 contains a depressed channel with a minimum sound speed at 20 m and a maximum sound speed at 79 m. Profile 2 is not an average profile in the same sense that profiles 1 and 3 are, since the profile shapes in the transition water volume are gradually changing from profile 1 shape to profile 3 shape. Profile 2, besides being characterized by an 11-m surface channel, contains two minor depressed channels. During the run the source ship reported 10- to 12-knot winds, 2-ft waves, and 3-ft swell. The receiver ship reported 8- to 10-knot winds, 1-ft waves, and 3- to 5-ft swell. No Waverider buoy measurements were obtained during this run. Receiver 1 was in the surface channel, receivers 2 and 3 were in the depressed channel, and receivers 4 and 5 were in the main thermocline.

AMOS Parameters

The AMOS propagation loss prediction model assumes that sources and receivers are in the same water volume, in which single values of the AMOS parameters are applicable. This assumption is valid out to a range of 34.6 kyd. The number of observations and the average values of these parameters, derived from the thermistor chain temperature measurements, and applicable to the run 3 experiment are:

number of observations	2448
isothermal layer depth	295 ft
surface water temperature	59.4°F
sea state	1-3

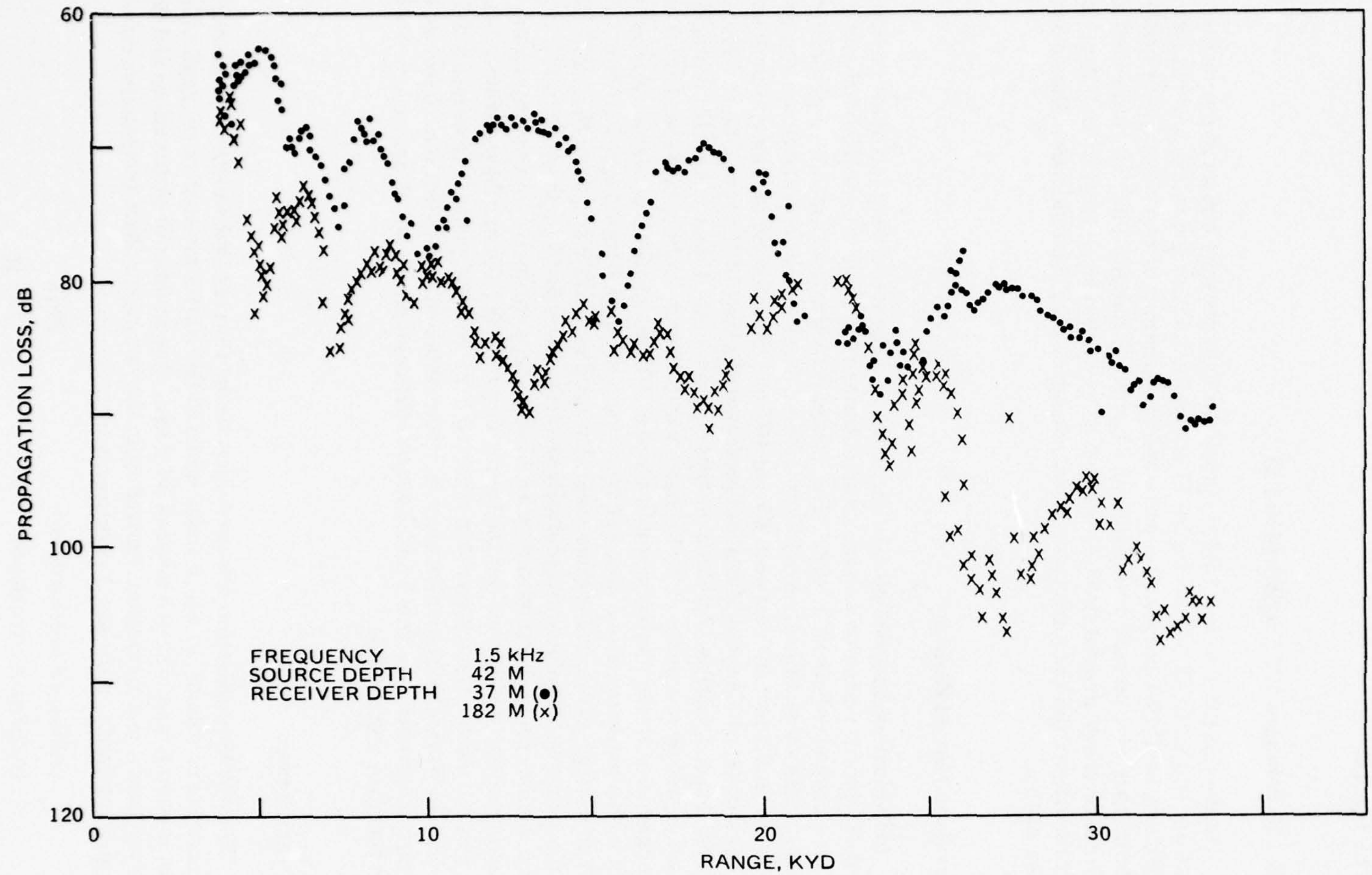


Figure 10. Station 3, run 2 Depth dependence.

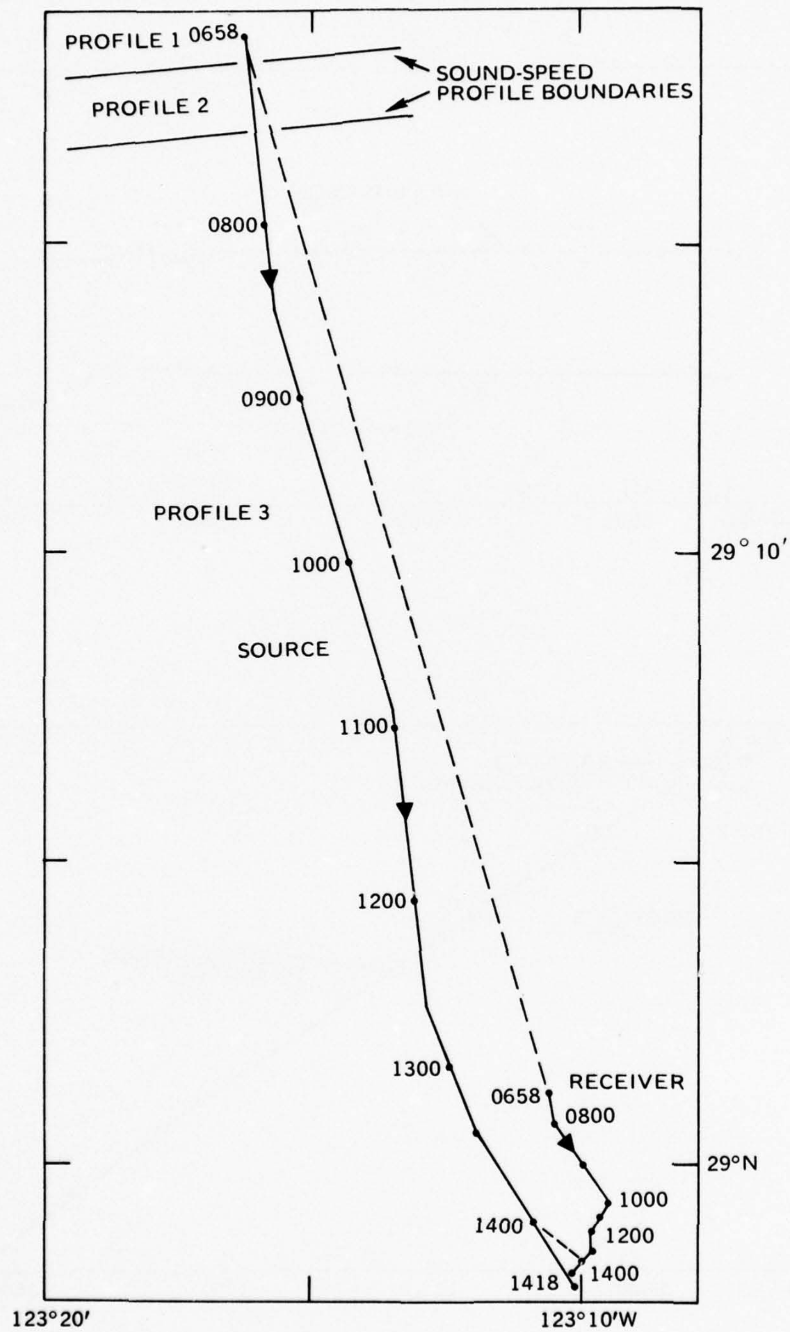


Figure 11. Station 3, run 3 Tracks of source and receiver ships, 0658 LST and 1400 LST propagation paths, and locations of sound-speed profile boundaries.

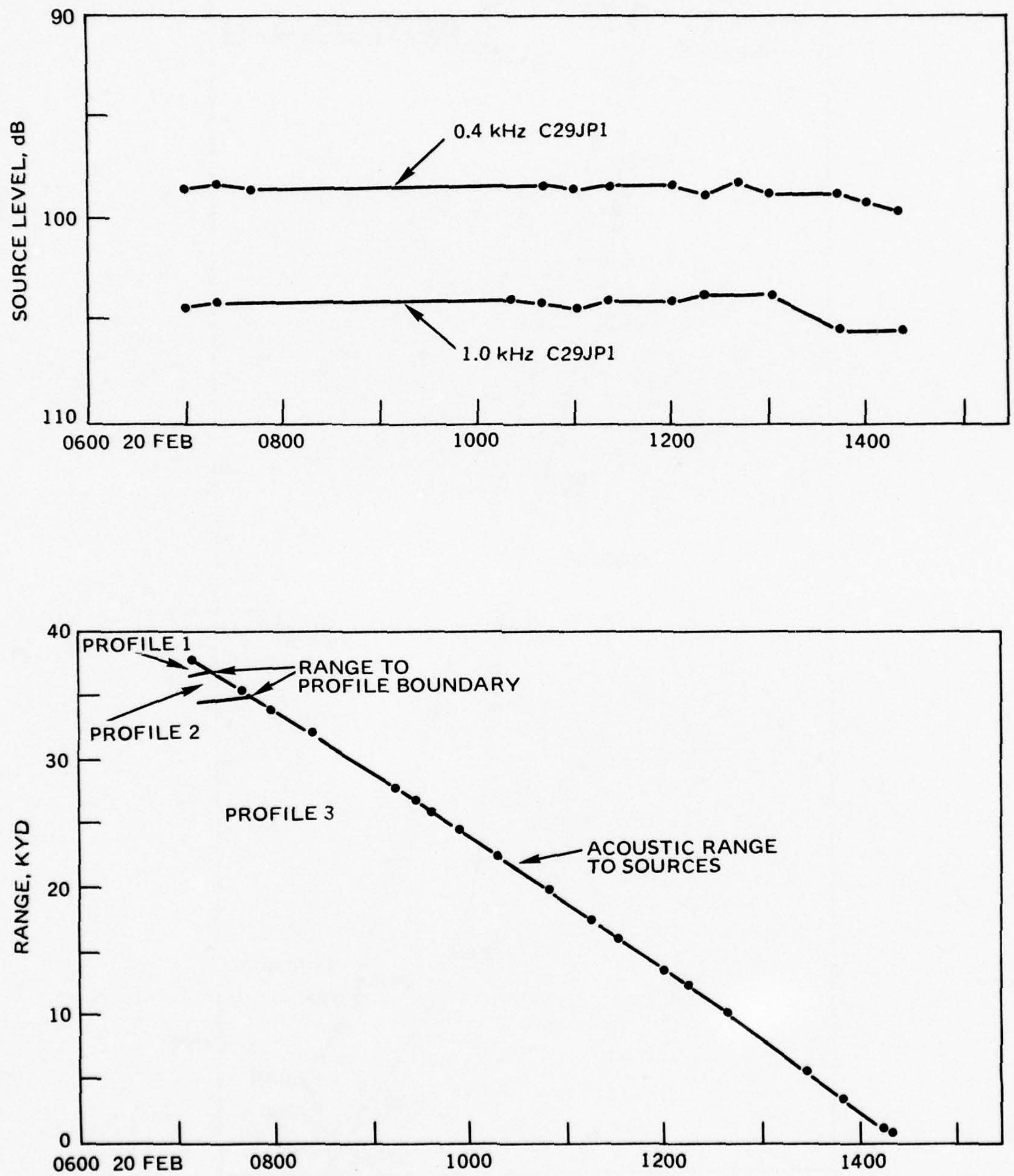


Figure 12. Station 3, run 3. Source level and range to receiver versus time of day (LST).

Discussion

The propagation loss measurements are summarized in Appendix C. Between 5.7 and 7.9 kyd both sources malfunctioned. Hence, no arrivals were recorded over this range interval. A visual comparison of these plots suggests the following:

- The most obvious feature of the propagation loss plots is the rapid increase in 0.4-kHz propagation loss out to a range that is a function of receiver depth. These ranges are:

receiver 1	6 kyd	receiver 4	12 kyd
receiver 2	8 kyd	receiver 5	12 kyd
receiver 3	10 kyd		

From the above ranges to the maximum range, the average propagation loss is almost independent of range for all receivers. This is illustrated for two receivers in Fig. 13.

- At 0.4 kHz the greatest propagation losses were recorded by the 6-m receiver. An inspection of this plot shows many below-noise missing arrivals for range greater than about 13 kyd.

- The 1.0-kHz propagation loss pattern recorded, for ranges greater than about 15 kyd (receivers 1, 2, and 3) and 7 kyd (receivers 4 and 5), is completely different from that recorded at 0.4 kHz. The 1.0-kHz propagation loss exhibits a systematic pattern typical of modal interference. Figure 14 is an example of this frequency difference. For clarity the propagation loss scales are offset by 30 dB.

RUN 4 20 February 1972, 1530-2052 LST

During this run, 3.5- and 5.0-kHz propagation losses were measured over acoustic ranges from 100 yd to 33.3 kyd. Figure 15 shows the track of the source and receiver ships and the 1800 and 2052 LST propagation paths. Between 1640 and 1710 LST the source ship made a 45-deg course change. This course change was made in an attempt to parallel the Teletherm buoy line at a range of about 1 nm from 1531 LST to about 1710 LST. However, it also resulted in propagation paths that do not parallel the course of the source ship. After 1700 LST the environmental measurements made by the source ship are not necessarily descriptive of environmental conditions in the propagation path planes. Figure 16 contains plots of source level and ranges from receivers, derived from 16 travel-time measurements versus time of day. The change in slope in this relationship is the result of the 45-deg course change executed by the source ship between 1640 and 1710 LST.

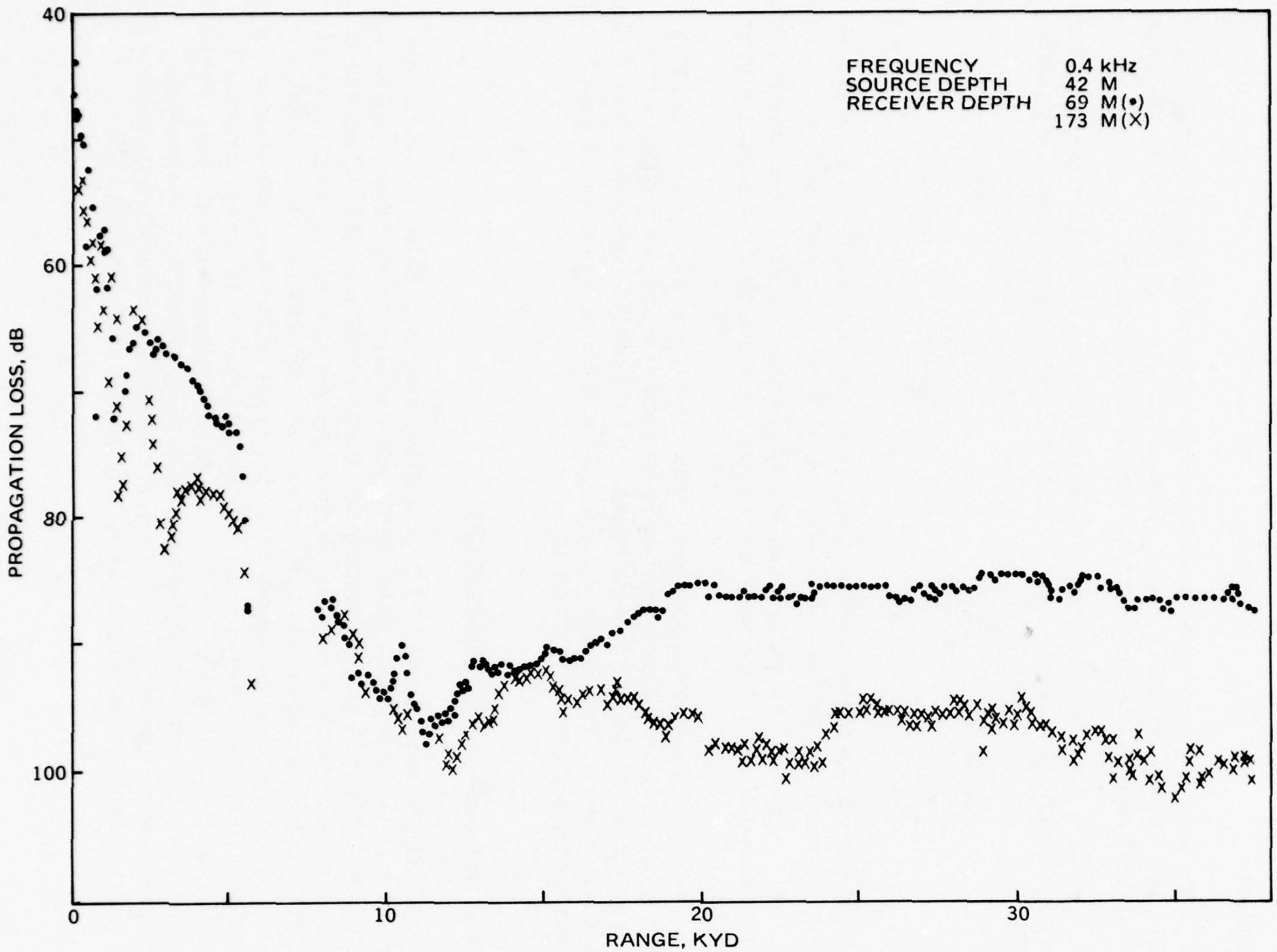


Figure 13. Station 3, run 3. Range dependence.

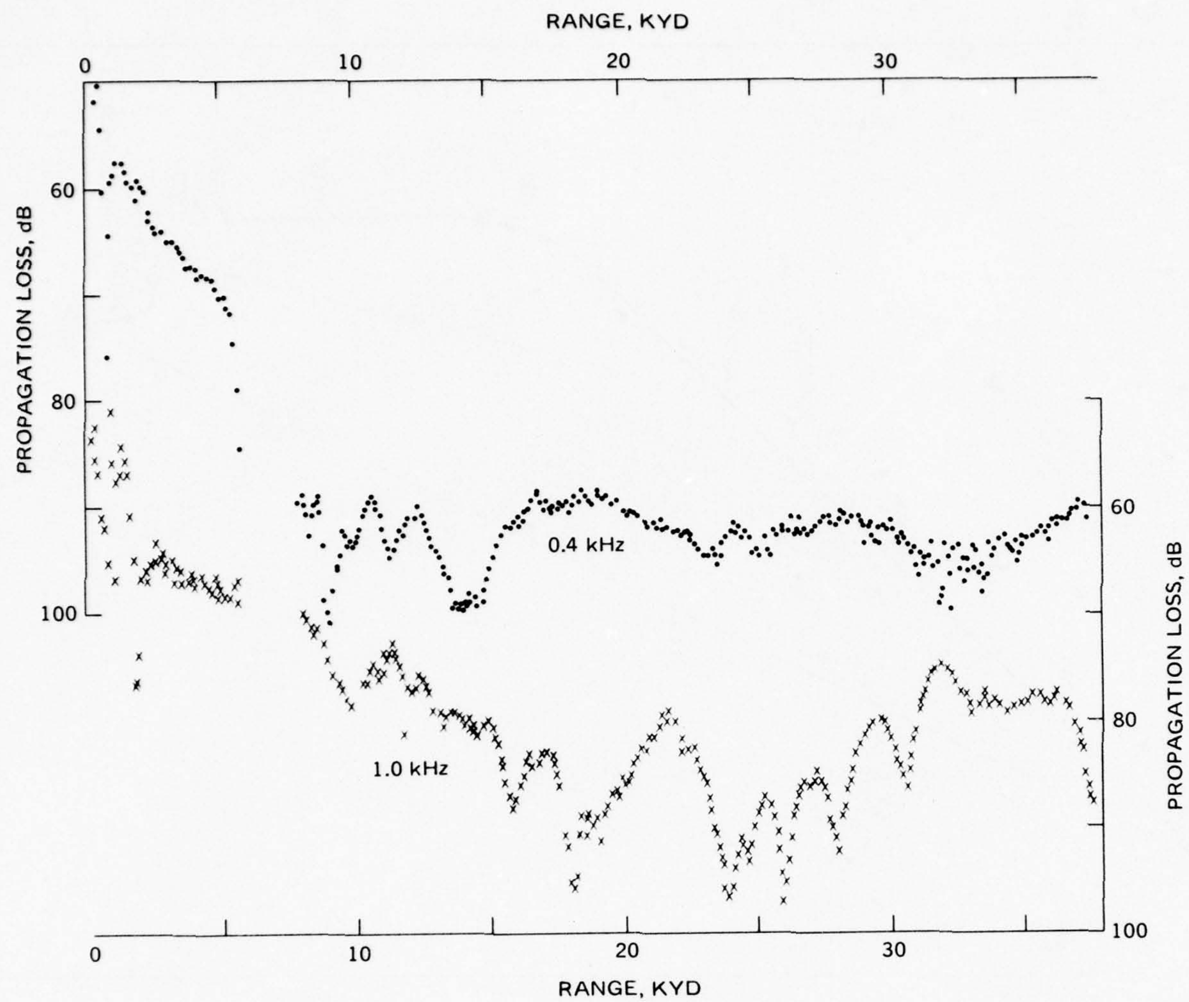


Figure 14. Station 3, run 3. Propagation loss for 42-m source and 34-m receiver.

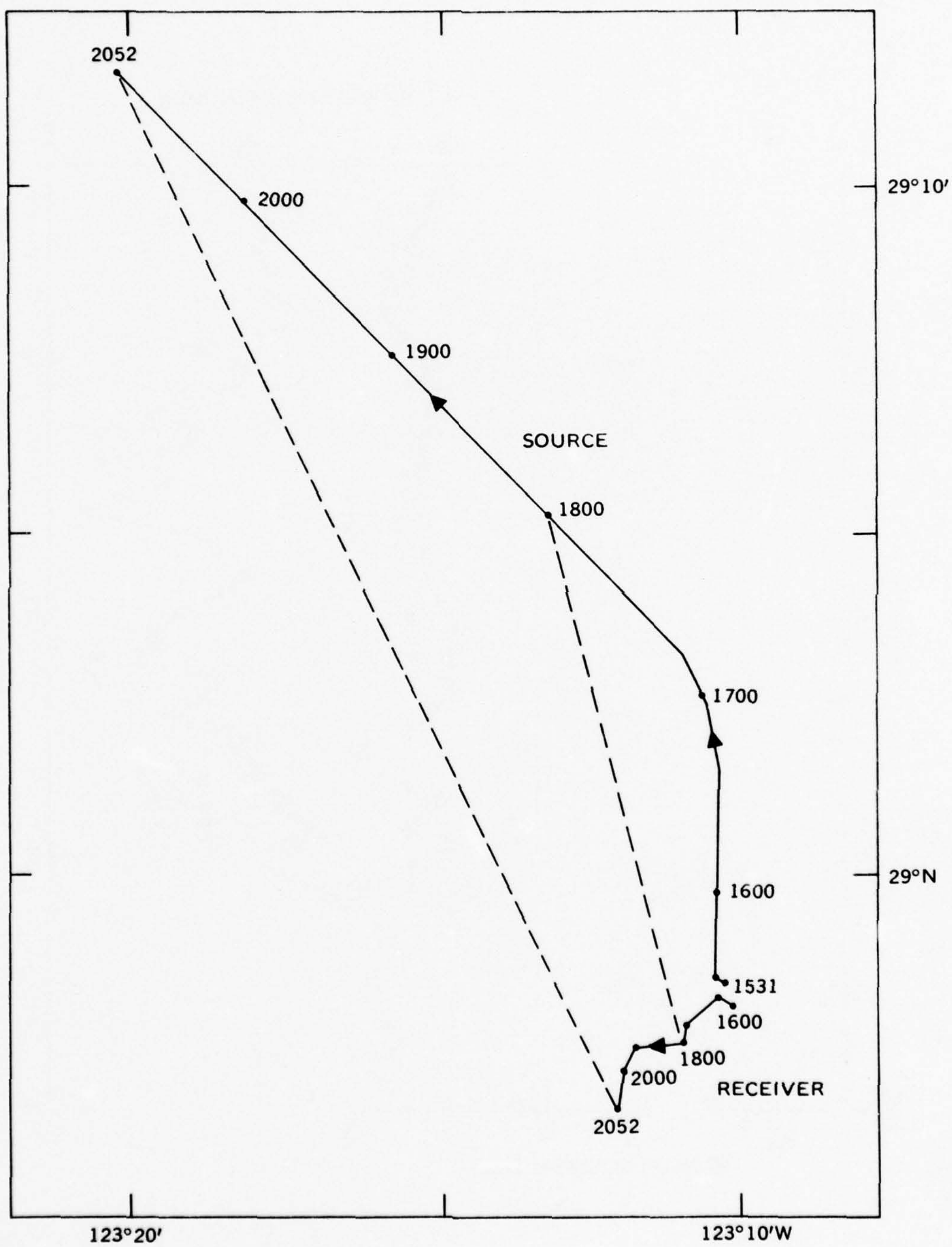
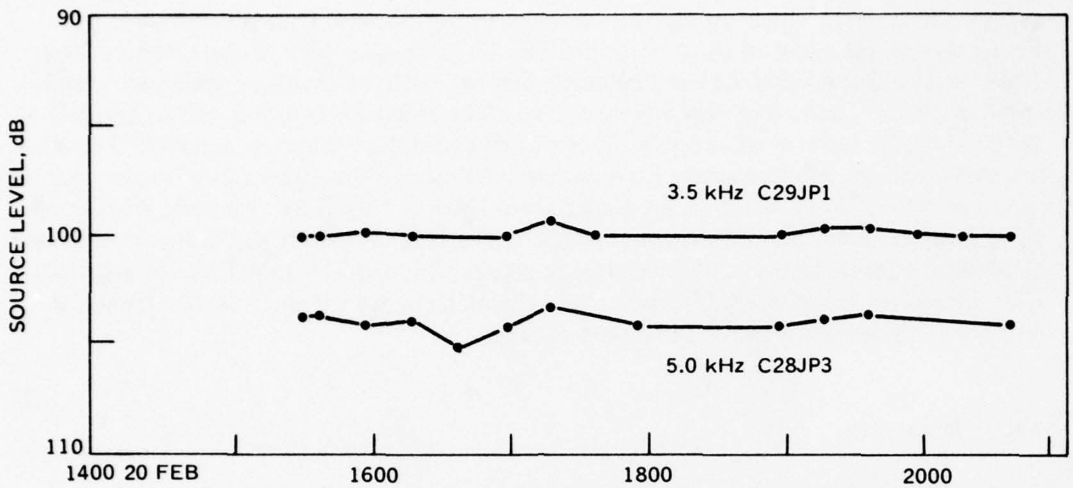


Figure 15. Station 3, run 4. Tracks of source and receiver ships and 1800 LST and 2052 LST propagation paths.



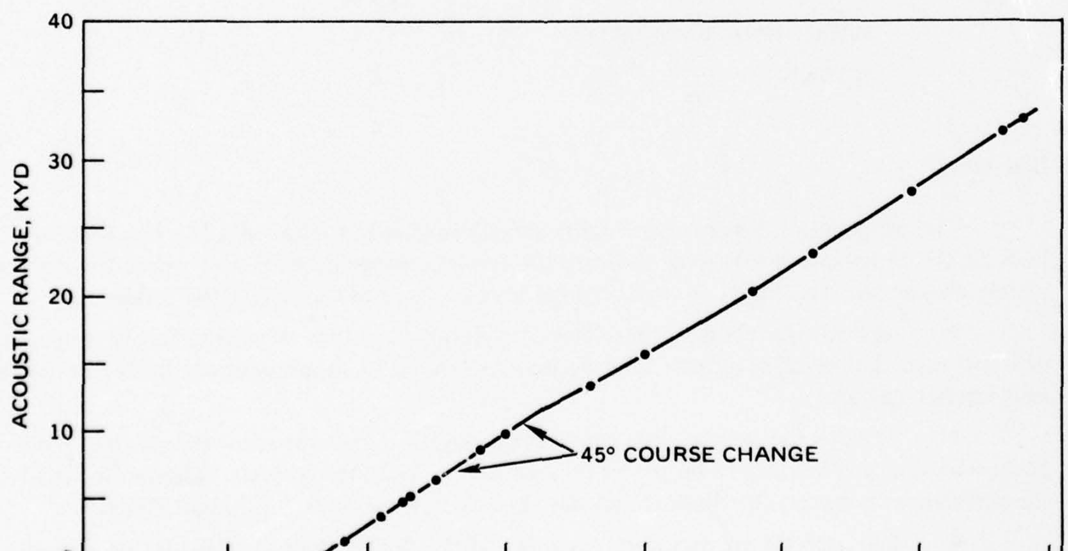


Figure 16. Station 3, run 4. Source level and range to receiver versus time of day (LST).

Average Sound-Speed Profile

Individual sound-speed profiles contain intermittent surface channels to depths of 50 m and small depressed channels, sometimes multiple, from 10 to 75 m. The data were averaged to obtain a single average sound-speed profile applicable to the complete run. Figure 5 contains a plot of the average profile. The average profile is characterized by a 10-m surface channel and a 65-m depressed channel, with the depth of minimum sound speed at 30 m. The source ship reported 7- to 10-knot winds, 1- to 2-ft waves, and 3-ft swell, while the receiver ship reported 7- to 11-knot winds, 1-ft waves, and 3- to 5-ft swell. Sea-surface roughness measurements were obtained by the Waverider buoy for the complete run except for a 2-min break in the record from 1801 to 1803 LST. Spectral analysis of these measurements showed that most of the sea-surface roughness was in the wave-period band from 12.0 to 15.0 sec. A smaller peak is present in the 1.5- to 4.5-sec wave-period band. Receiver 1 was located in the surface channel, receivers 2 and 3 in the depressed channel and receivers 4 and 5 in the thermocline.

AMOS Parameters

The number of observations and the average values of these parameters, derived from the thermistor chain temperature measurements and applicable to the run 4 experiment, are:

number of observations	1944
isothermal layer depth	36 ft
depressed channel axis	112 ft
surface water temperature	59.5°F
sea state	2

Discussion

The propagation loss measurements are summarized in Appendix D. The vertical lines on the propagation loss plots indicate the acoustic range interval over which the 45-deg course change was executed. A visual comparison of these plots suggest the following:

- At both frequencies, there was considerable random variability in the propagation loss recorded by all receivers. This variability tended to suppress or diminish any modal interference patterns.
- At both frequencies, the smallest propagation loss was recorded on the 6- and 36-m receivers and the largest on the 180-m receiver. For ranges greater than about 8 kyd the differences between the shallow and deep receivers were up to a nominal 20 dB.
- The 5.0-kHz propagation loss was slightly greater than the 3.5-kHz propagation loss; however, the differences were not consistent or marked.

RUN 5 20-21 February 1972, 2130-0400 LST

Figure 17 shows the track of the source and receiver ships and the 2130 and 0400 LST propagation paths. Between 2315 and 0040 LST the source ship made several course changes, resulting in propagation paths that do not parallel the track of the source ship. The environmental measurements made by the source ship are not necessarily descriptive of environmental conditions in the propagation path planes. Figure 18 contains plots of source level and ranges from receivers, derived from 17 travel-time measurements, versus time of day.

Average Sound-Speed Profile

Individual sound-speed profiles show transient surface channels varying in depth from 6 to 50 m and a few depressed channels from 20 to 85 m. Figure 5 contains a plot of the average profile. The average profile is characterized by a 10-m surface channel and a minor depressed channel with the minimum sound speed at 20 m. Beneath the depressed channel is an isospeed layer about 40 m thick. During this experiment the source ship reported 6-knot winds, 1-ft waves, and 3-ft swell, while the receiver ship reported light airs to 6-knot winds, 1-ft waves, and 3-ft swell. Also sea-surface roughness measurements were obtained by the Waverider buoy from 0001 to 0300 LST on 21 February 1972. No measurements were obtained by the Waverider buoy at the beginning or end of the run. Spectral analysis of these measurements shows that most of the sea-surface roughness was in the wave-period band from 11.5 to 14.0 sec. A smaller peak in the roughness was centered at about 3.5 sec. Receiver 1 was located in the surface channel, receivers 2 and 3 in the isospeed layer, and receivers 4 and 5 in the thermocline.

AMOS Parameters

The number of observations and the average values of these parameters, derived from the thermistor chain temperature measurements and applicable to the run 5 experiment, are:

number of observations	2286
isothermal layer depth	259 ft
surface water temperature	59.5°F
sea state	2

Discussion

The propagation loss measurements are summarized in Appendix E. The vertical lines on the propagation loss plots indicate the acoustic range interval over which the course change was executed. A visual comparison of these plots suggests the following:

- The 3.5-kHz propagation loss plots exhibit better-developed modal interference patterns than the 5.0-kHz plots.

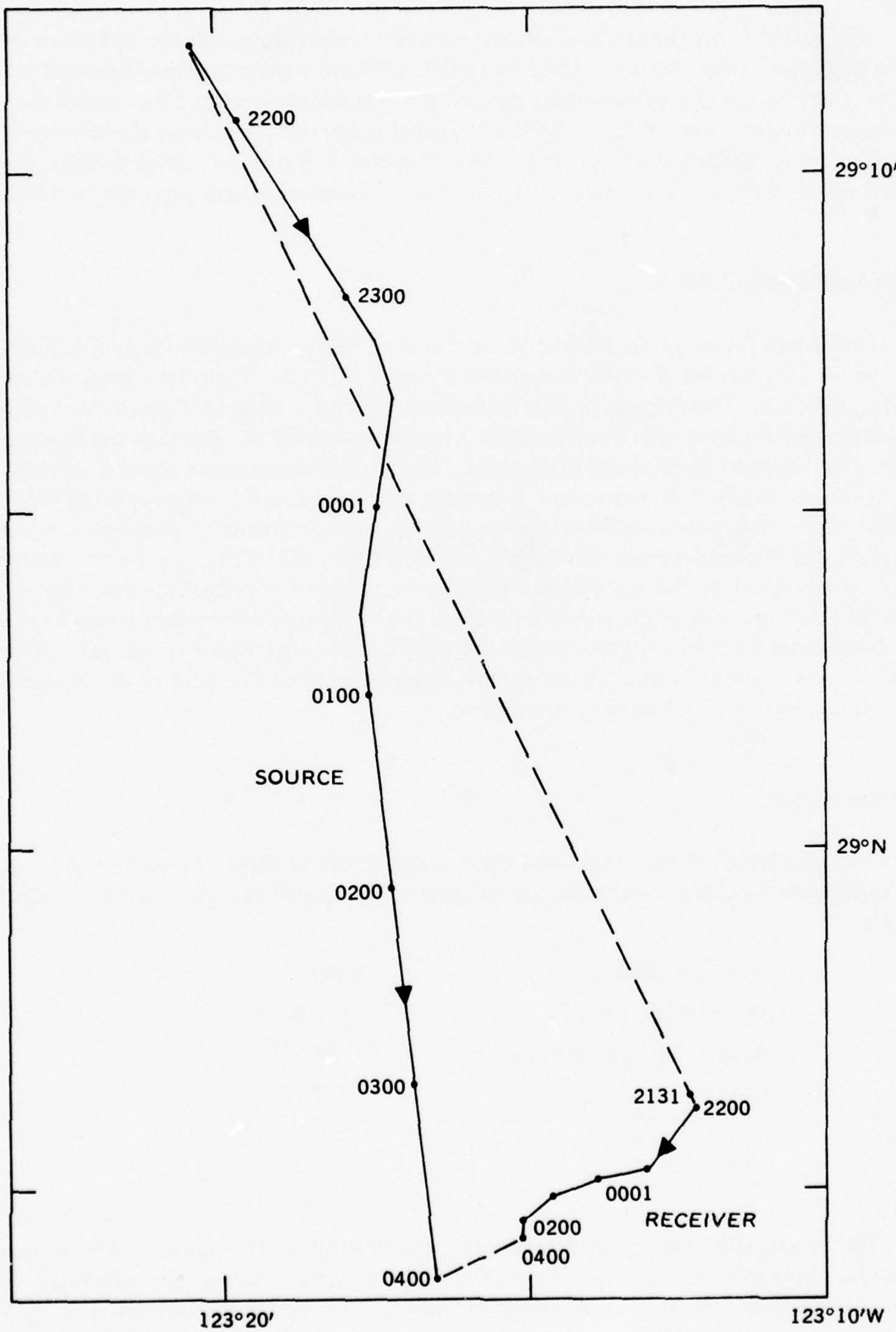
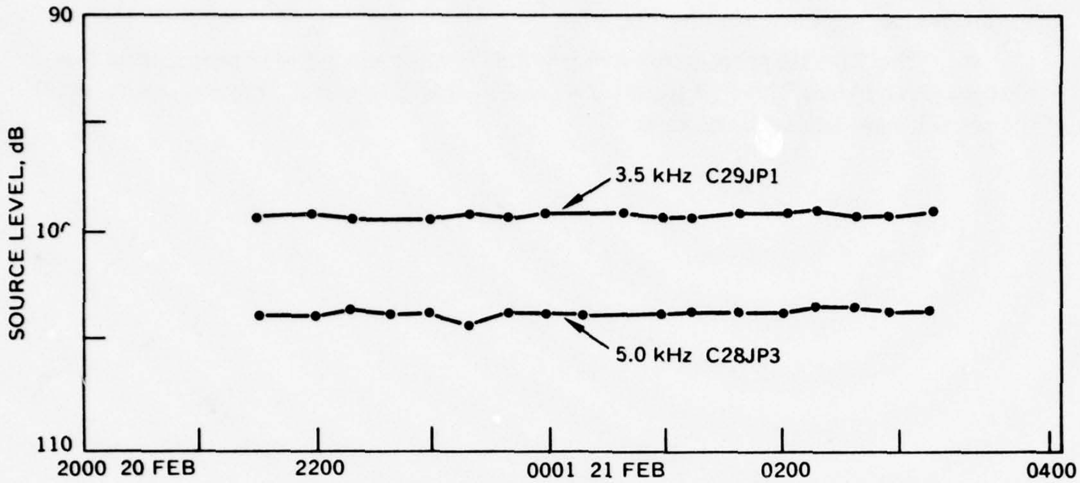


Figure 17. Station 3, run 5. Tracks of source and receiving ships and 2131 LST and 0400 LST propagation paths.



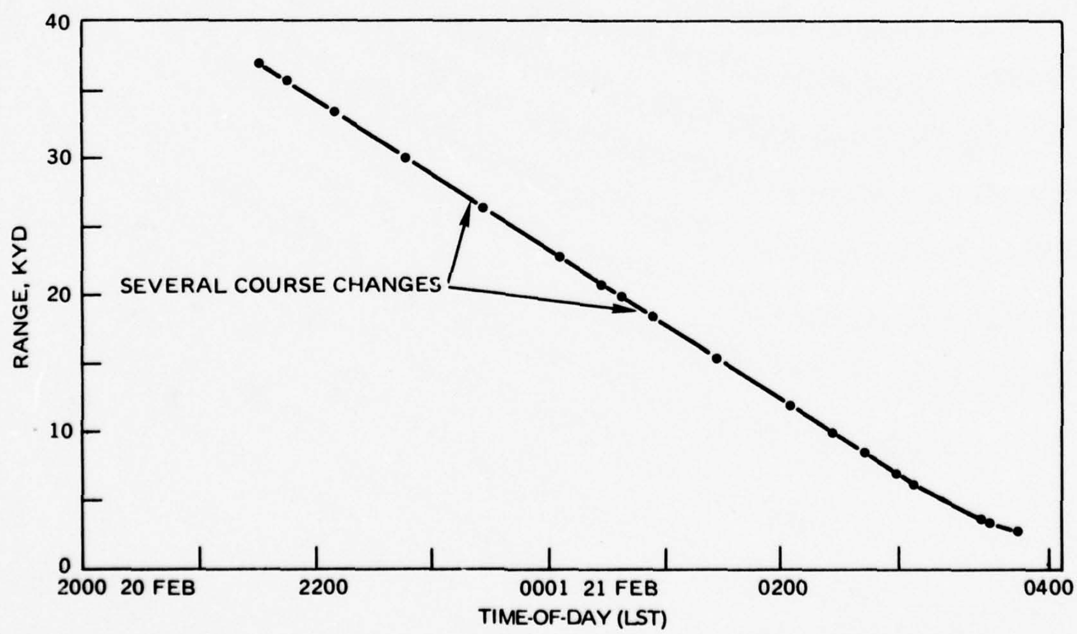


Figure 18. Station 3, run 5. Source level and acoustic range versus time of day (LST).

- At both frequencies the smallest propagation loss was recorded by the 6-m receiver and the largest by the 177-m receiver for acoustic ranges less than about 17 kyd. These differences are illustrated by Fig. 19.

- The 5.0-kHz propagation loss was greater than the 3.5-kHz propagation loss. For ranges greater than 27.4 kyd (receiver 4) and 21.0 kyd (receiver 5), many, most, or all of the arrivals were below the noise level.

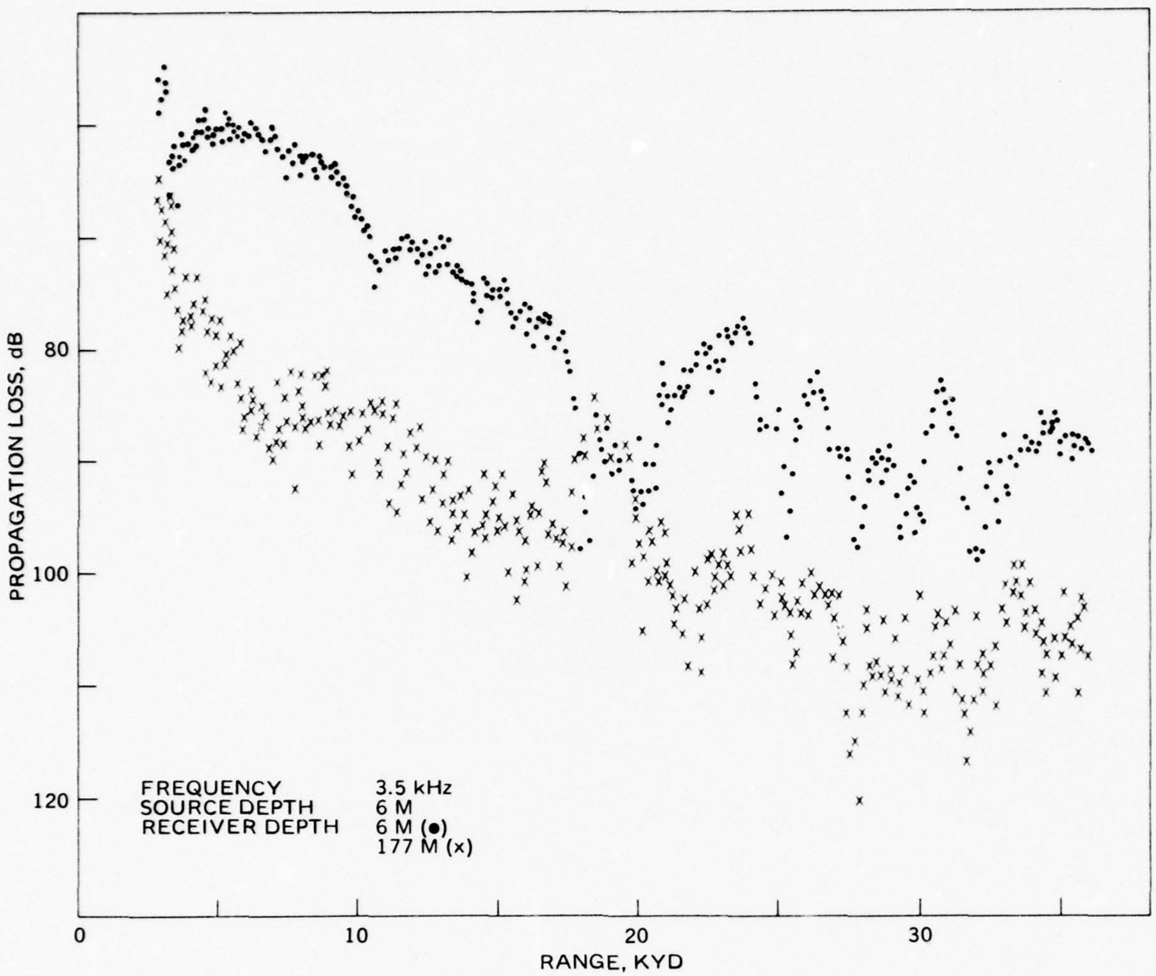
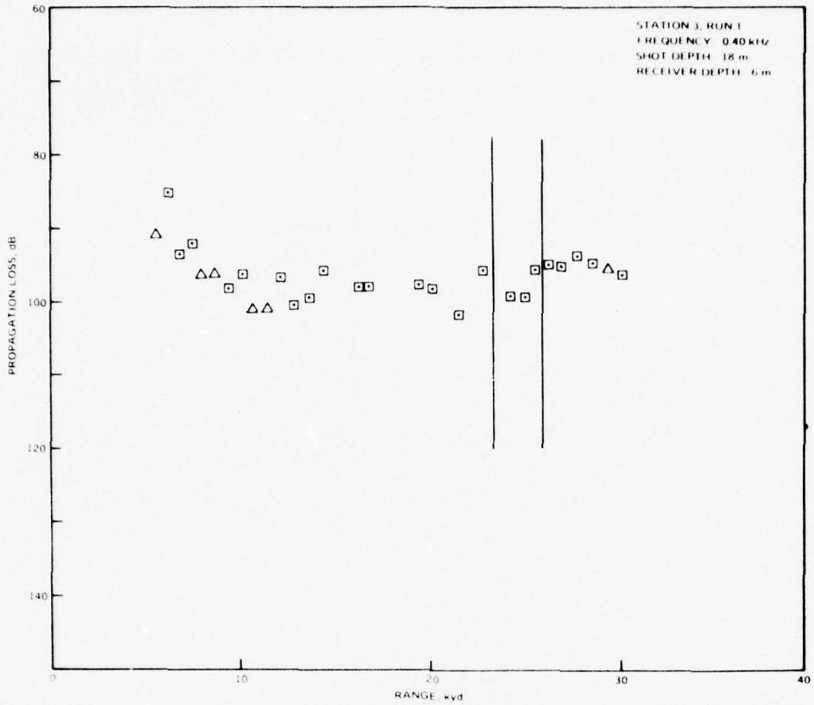


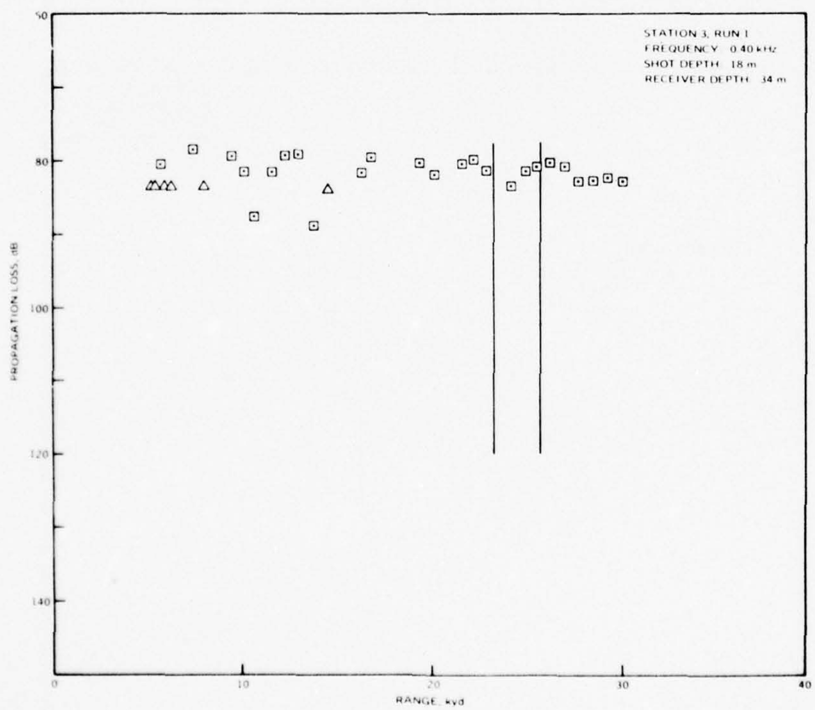
Figure 19. Station 3, run 5. Depth dependence.

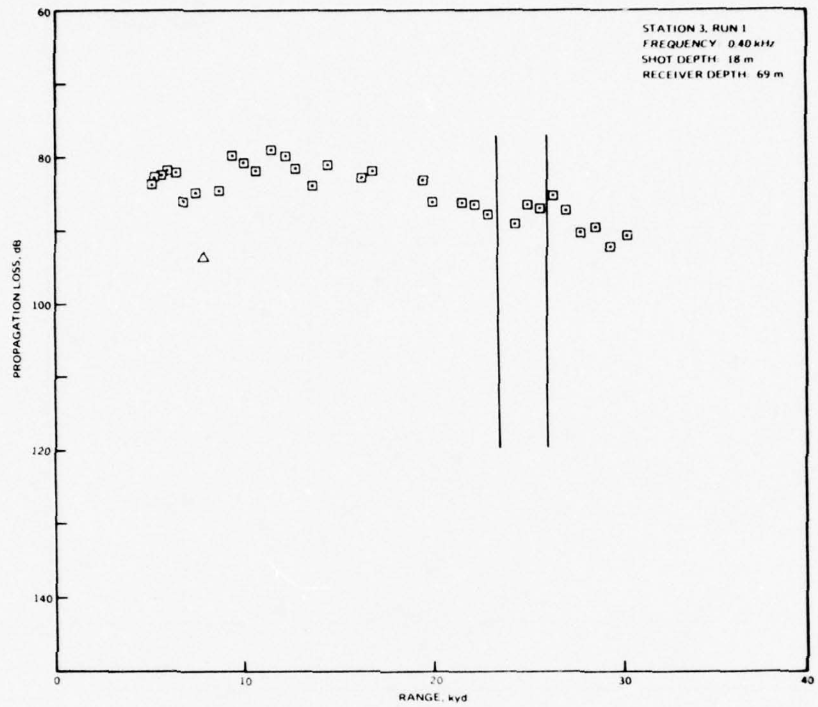
APPENDIX A

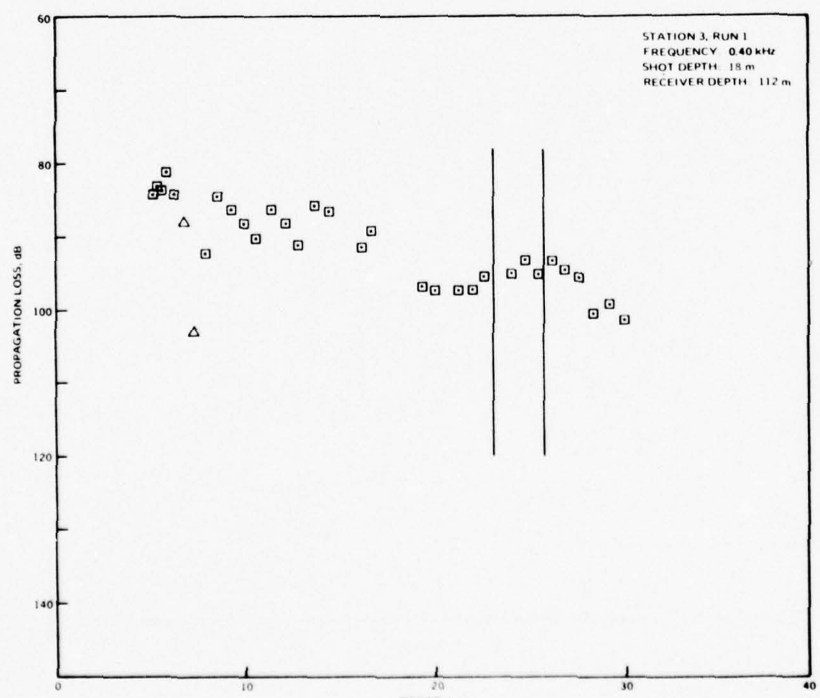
STATION 3 RUN 1

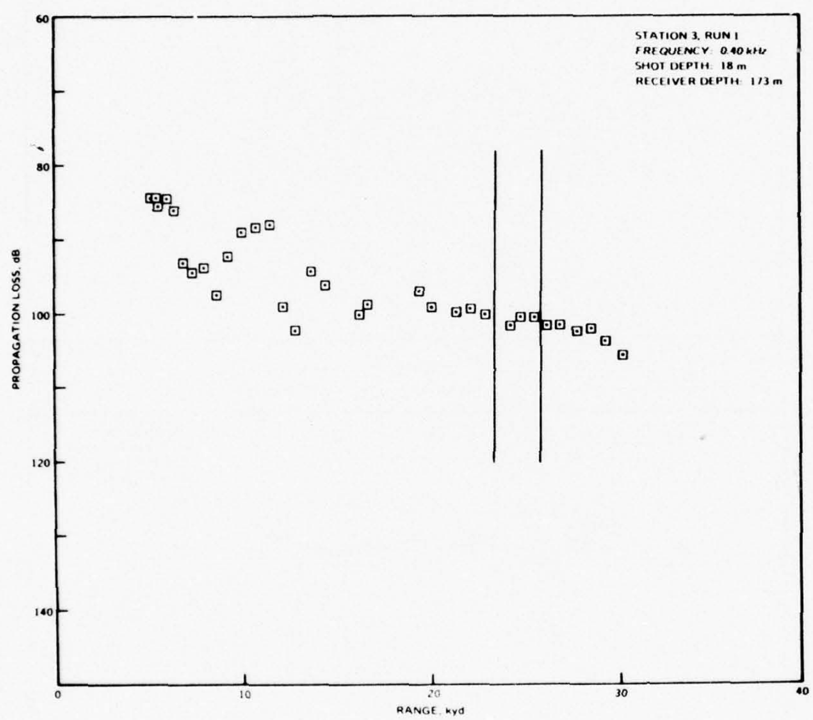
PROPAGATION LOSS VERSUS ACOUSTIC RANGE PLOTS


STATION 3, RUN 1
FREQUENCY 0.40 kHz
SHOT DEPTH 18 m
RECEIVER DEPTH 6 m
PROPAGATION LOSS, dB
60
80
100
120
140
0
10
20
30
40
RANGE, kyd

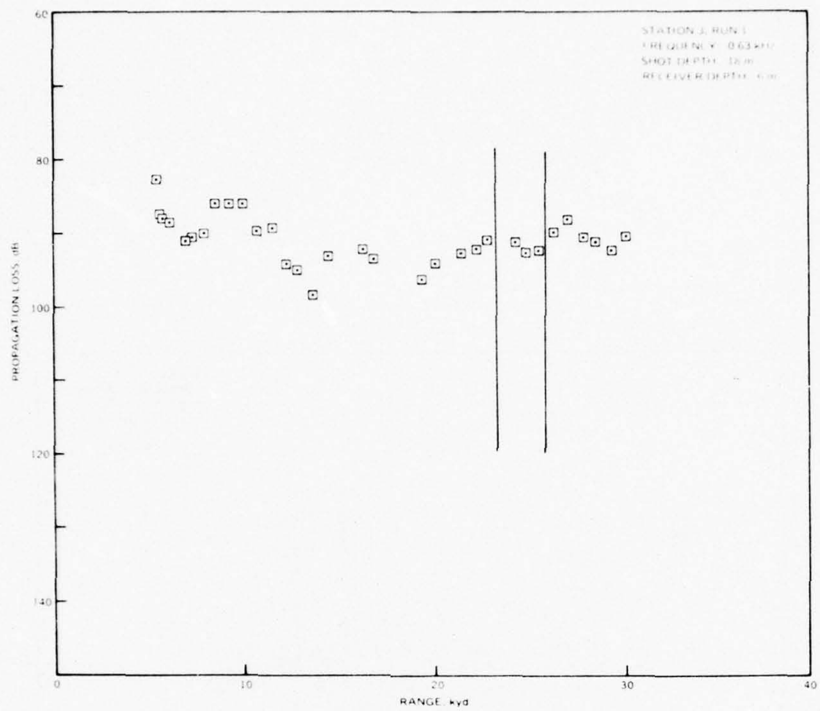

STATION 3, RUN 1
FREQUENCY 0.40 kHz
SHOT DEPTH 18 m
RECEIVER DEPTH 34 m
PROPAGATION LOSS, dB
60
80
100
120
140
0
10
20
30
40
RANGE, kyd

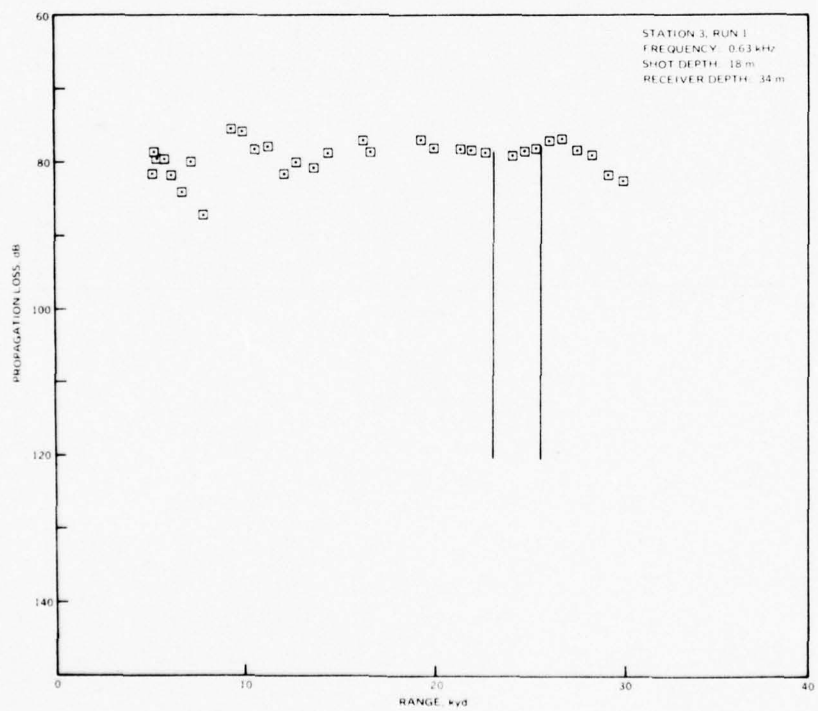

STATION 3, RUN 1
FREQUENCY: 0.40 kHz
SHOT DEPTH: 18 m
RECEIVER DEPTH: 69 m
PROPAGATION LOSS, dB
RANGE, kyd
60
80
100
120
140
0
10
20
30
40

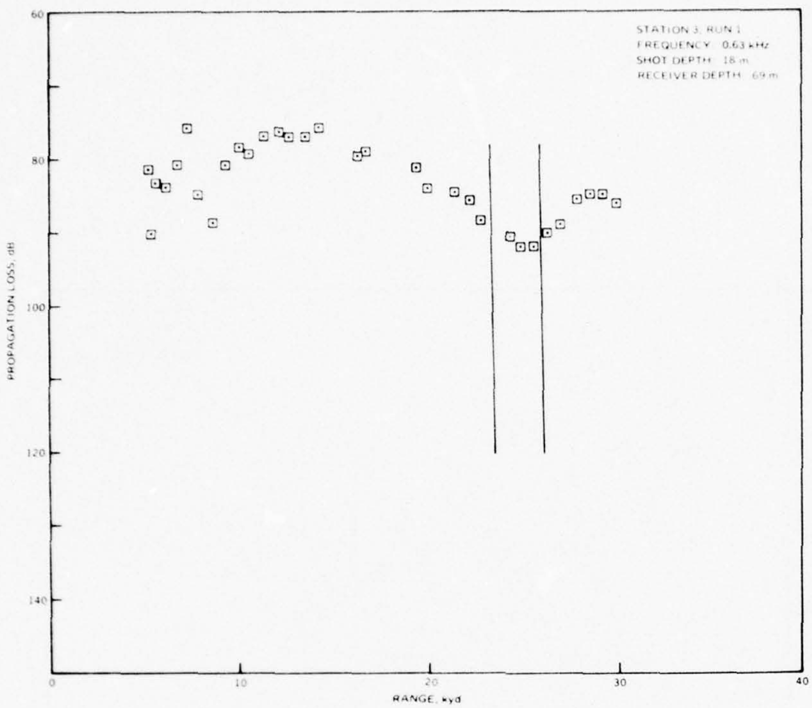

STATION 3, RUN 1
FREQUENCY: 0.40 kHz
SHOT DEPTH: 18 m
RECEIVER DEPTH: 112 m
PROPAGATION LOSS, dB
RANGE, kyd
60
80
100
120
140
0
10
20
30
40

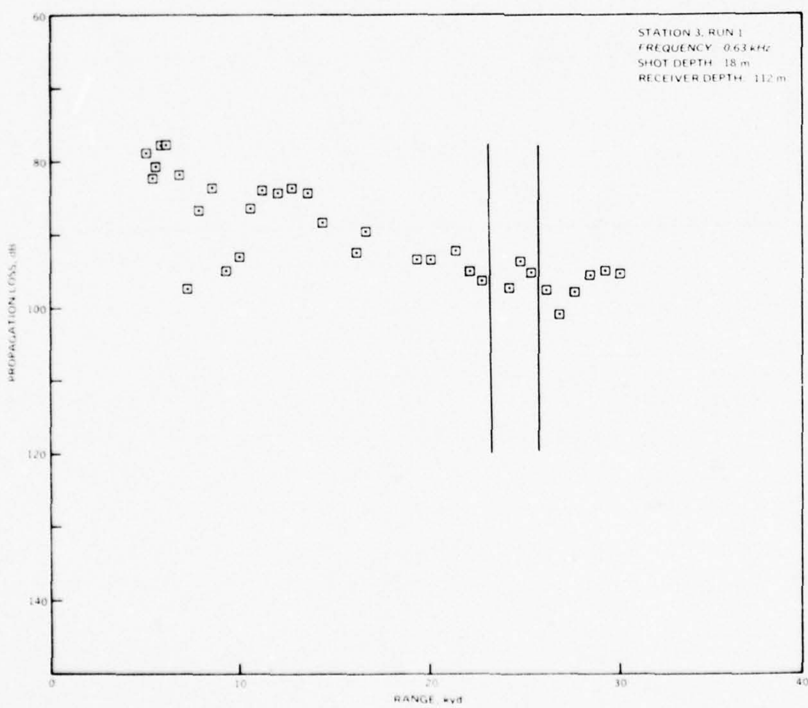


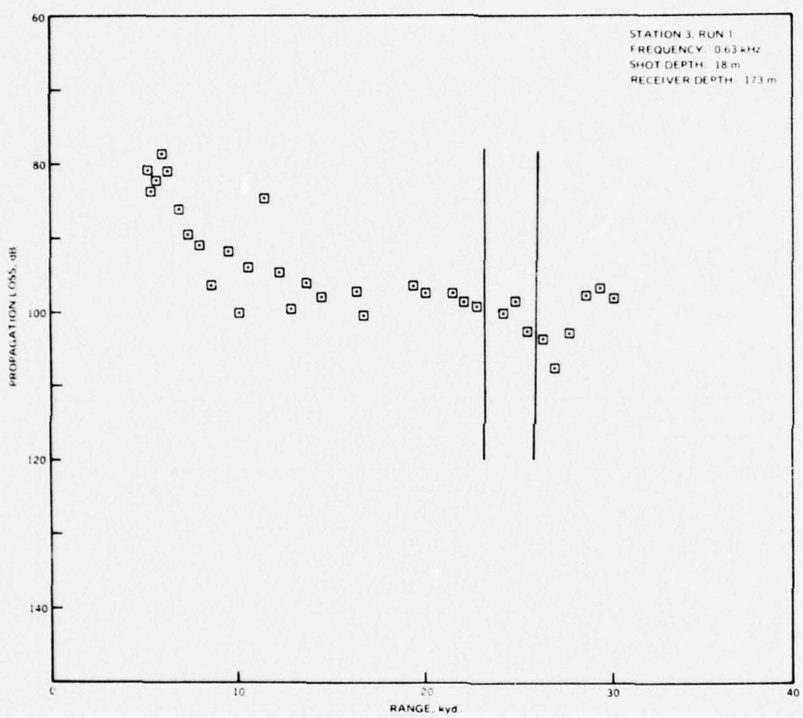
STATION 3, RUN 1
FREQUENCY: 0.40 kHz
SHOT DEPTH: 18 m
RECEIVER DEPTH: 173 m
PROPAGATION LOSS, dB
60
80
100
120
140
0
10
20
30
40
RANGE, kyd

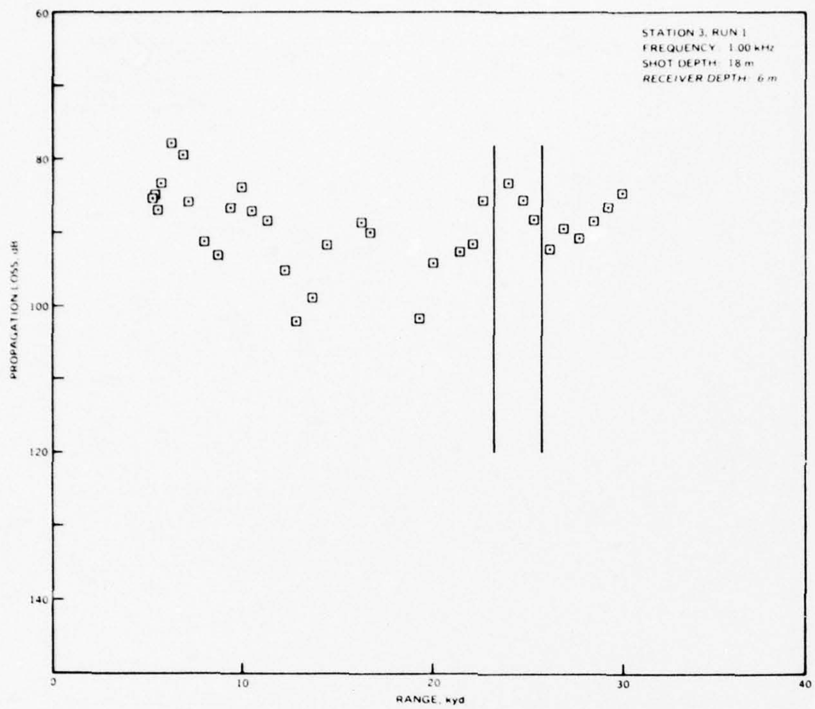

STATION 3, RUN 1
FREQUENCY: 0.63 kHz
SHOT DEPTH
RECEIVER DEPTH
60
80
100
120
140
PROPAGATION LOSS, dB
0
10
20
30
40
RANGE, kyd

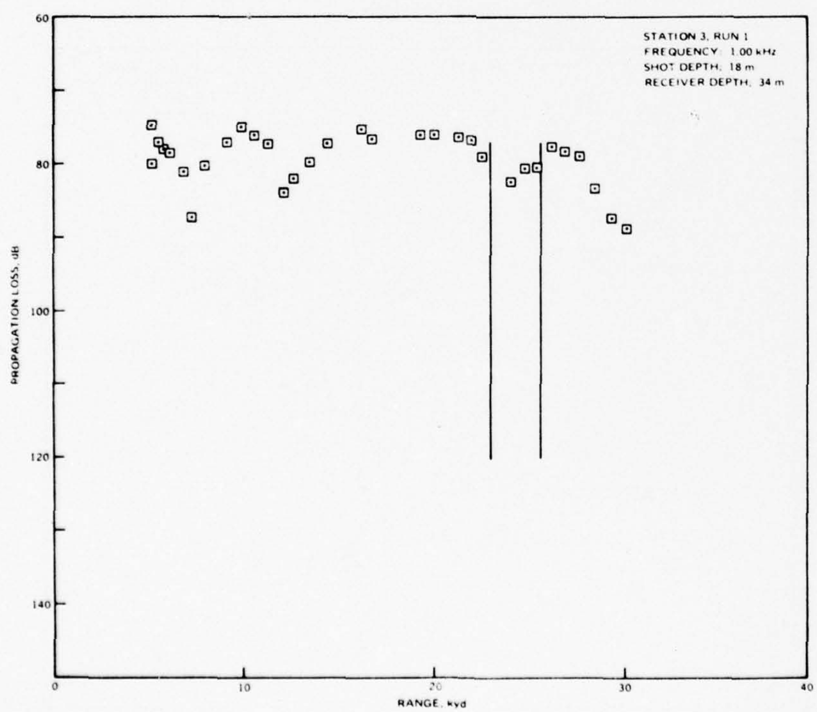

STATION 3, RUN 1
FREQUENCY: 0.63 kHz
SHOT DEPTH: 18 m
RECEIVER DEPTH: 34 m
60
80
100
120
140
PROPAGATION LOSS, dB
0
10
20
30
40
RANGE, kyd

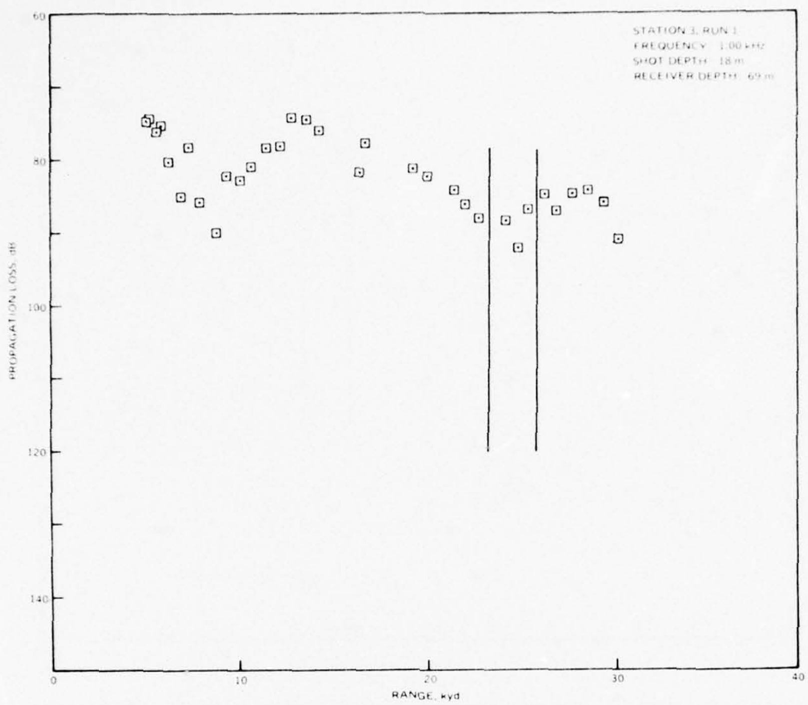

STATION 3, RUN 1
FREQUENCY: 0.63 kHz
SHOT DEPTH: 18 m
RECEIVER DEPTH: 69 m
PROPAGATION LOSS, dB
60
80
100
120
140
0
10
20
30
40
RANGE, kyd

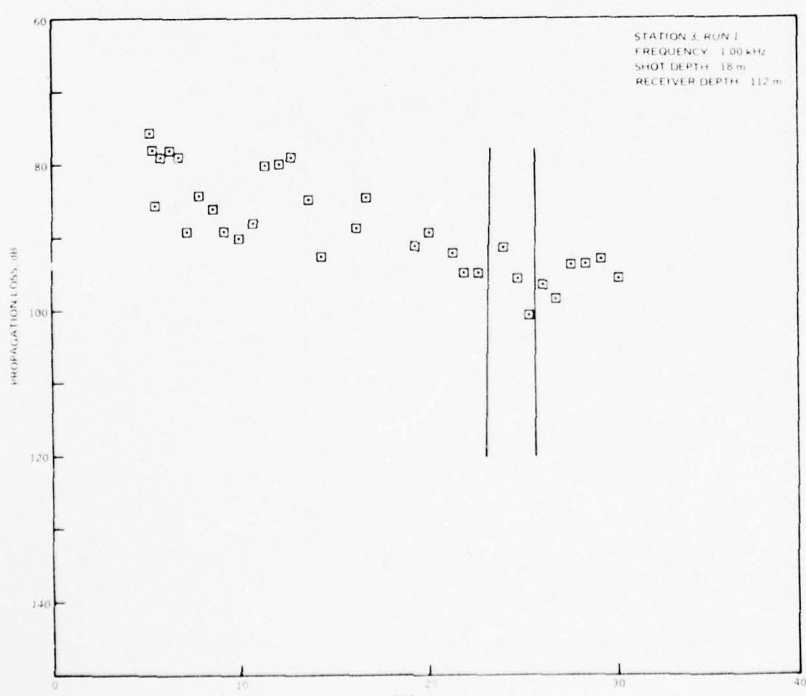

STATION 3, RUN 1
FREQUENCY: 0.63 kHz
SHOT DEPTH: 18 m
RECEIVER DEPTH: 112 m
PROPAGATION LOSS, dB
60
80
100
120
140
0
10
20
30
40
RANGE, kyd

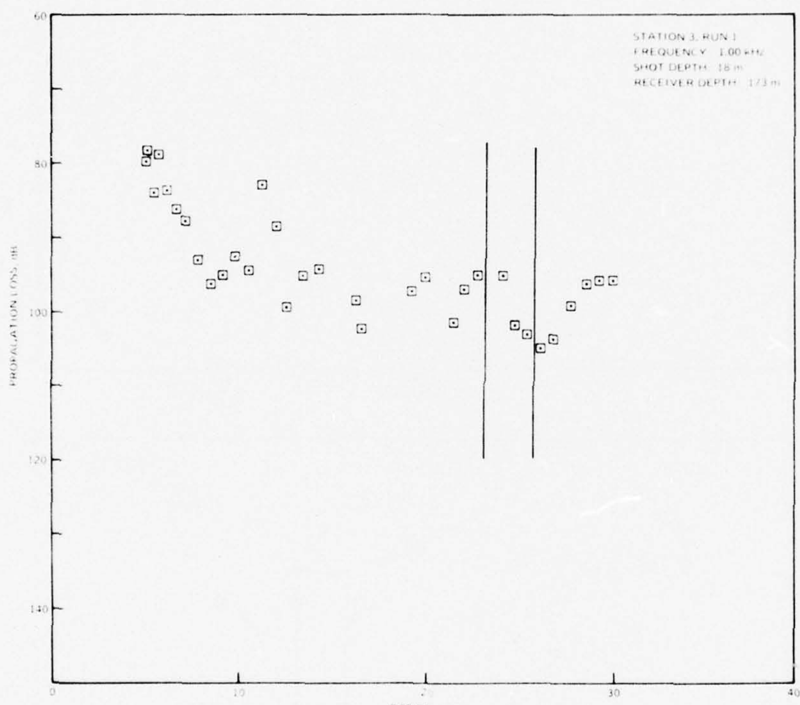

STATION 3, RUN 1
FREQUENCY: 0.63 kHz
SHOT DEPTH: 18 m
RECEIVER DEPTH: 173 m
PROPAGATION LOSS, dB
60
80
100
120
140
0
10
20
30
40
RANGE, kyd


STATION 3, RUN 1
FREQUENCY: 1.00 kHz
SHOT DEPTH: 18 m
RECEIVER DEPTH: 6 m
PROPAGATION LOSS, dB
RANGE, kyd
60
80
100
120
140
0
10
20
30
40

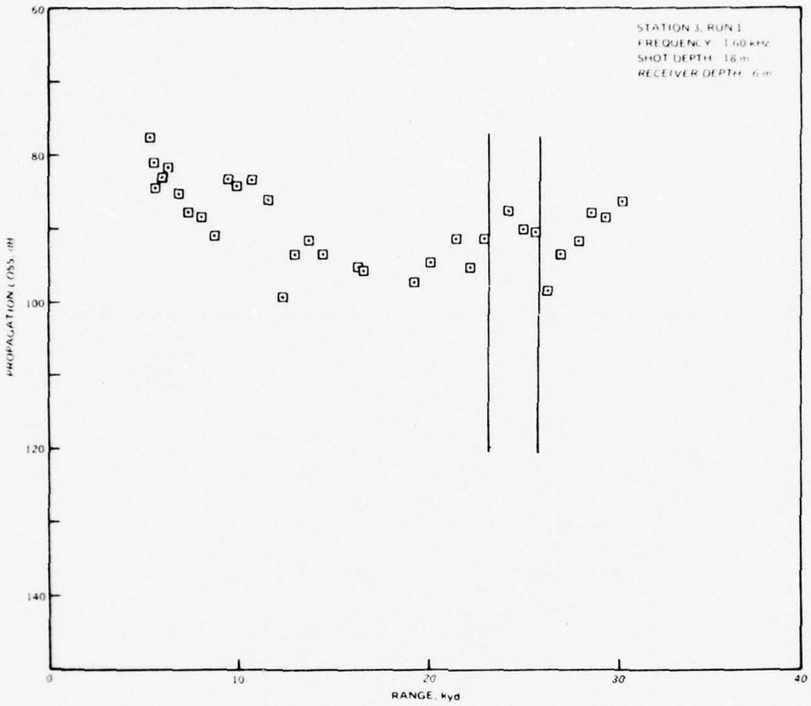

STATION 3, RUN 1
FREQUENCY: 1.00 kHz
SHOT DEPTH: 18 m
RECEIVER DEPTH: 34 m
PROPAGATION LOSS, dB
RANGE, kyd
60
80
100
120
140
0
10
20
30
40

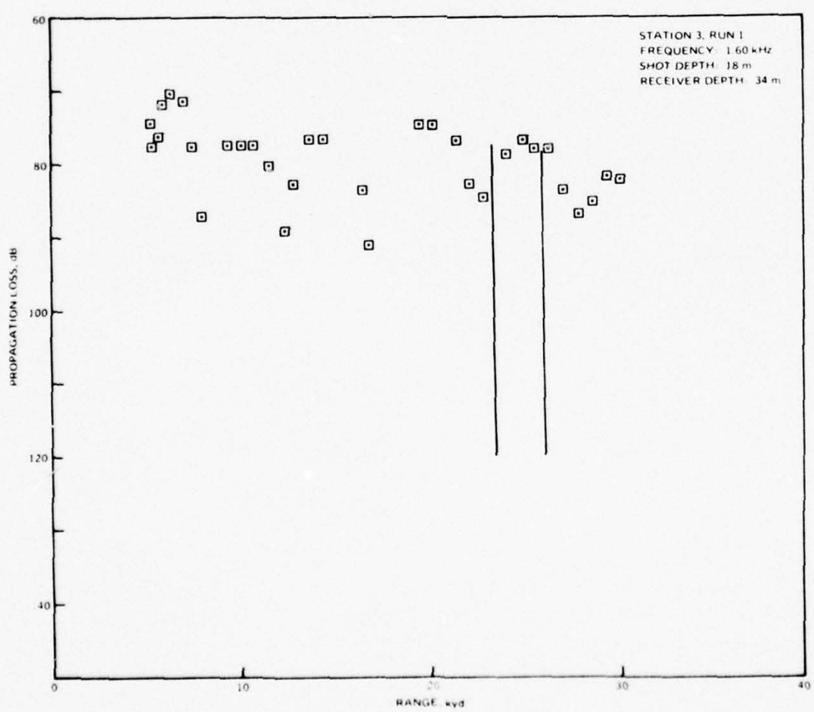

STATION 3, RUN 1
FREQUENCY 1.00 kHz
SHOT DEPTH 18 m
RECEIVER DEPTH 69 m
PROPAGATION LOSS, dB
60
80
100
120
140
0
10
20
30
40
RANGE, kyd

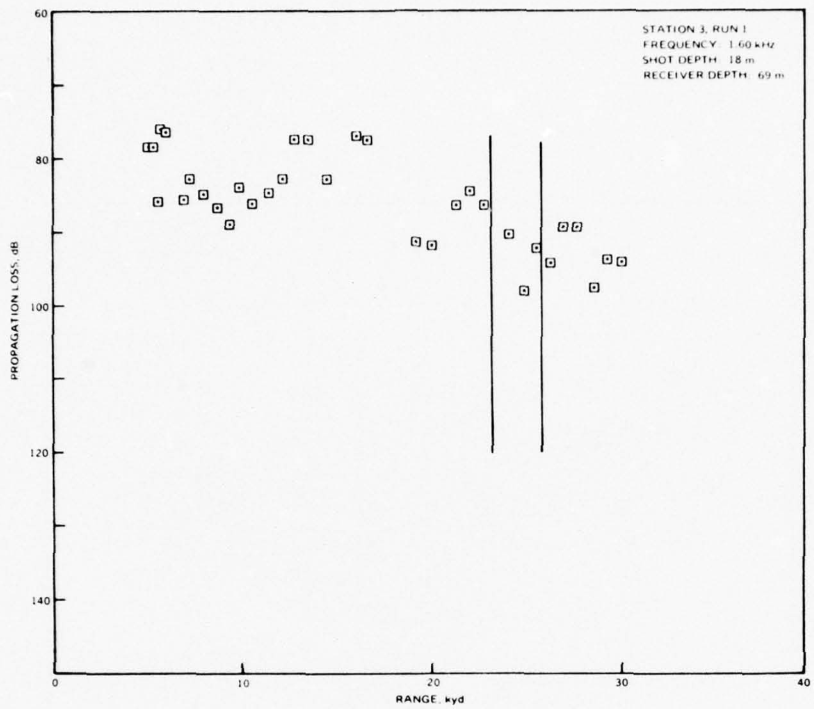

STATION 3, RUN 1
FREQUENCY 1.00 kHz
SHOT DEPTH 18 m
RECEIVER DEPTH 112 m
PROPAGATION LOSS, dB
60
80
100
120
140
0
10
20
30
40
RANGE, kyd

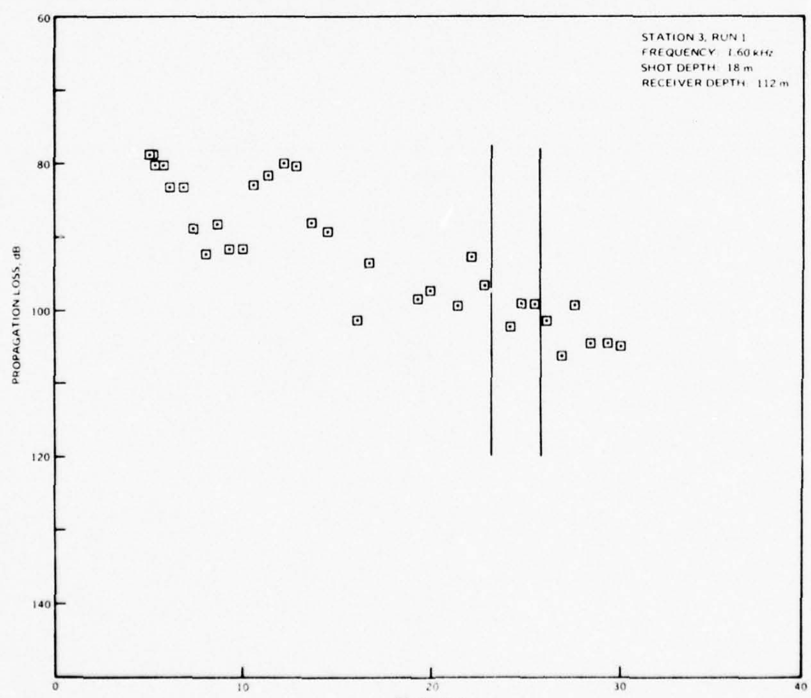


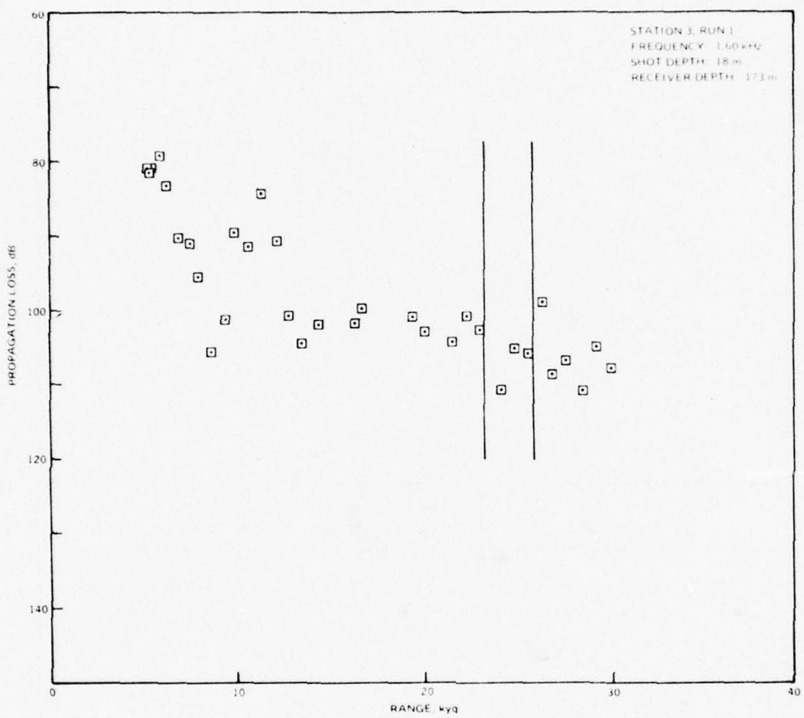
STATION 3, RUN 1
FREQUENCY 1.00 kHz
SHOT DEPTH 18 m
RECEIVER DEPTH 173 m
PROPAGATION LOSS, dB
60
80
100
120
140
0
10
20
30
40
RANGE, kyd


STATION 3, RUN 1
FREQUENCY: 1.60 kHz
SHOT DEPTH: 18 m
RECEIVER DEPTH: 6 m
PROPAGATION LOSS, dB
60
80
100
120
140
0
10
20
30
40
RANGE, kyd

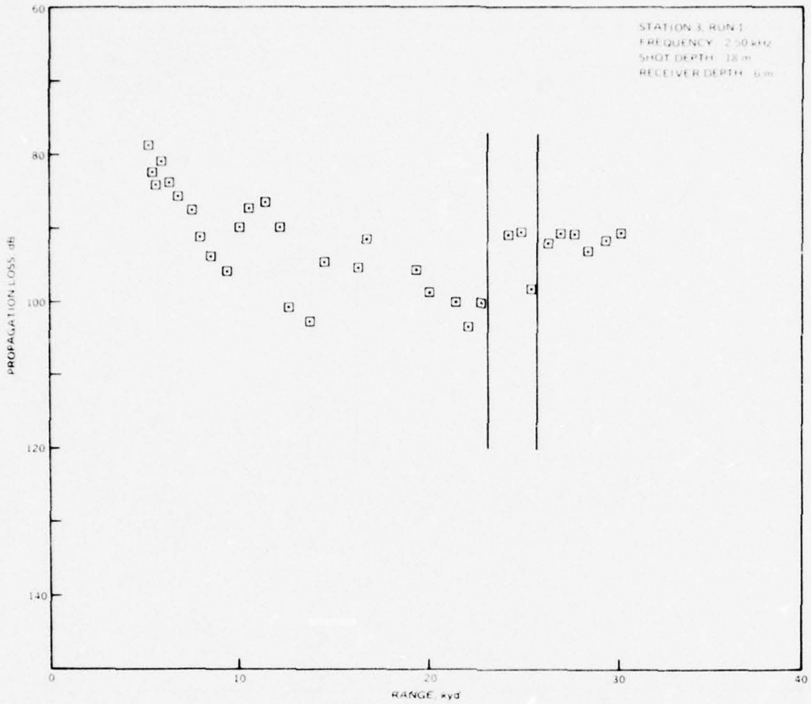

STATION 3, RUN 1
FREQUENCY: 1.60 kHz
SHOT DEPTH: 18 m
RECEIVER DEPTH: 34 m
PROPAGATION LOSS, dB
60
80
100
120
40
0
10
20
30
40
RANGE, kyd

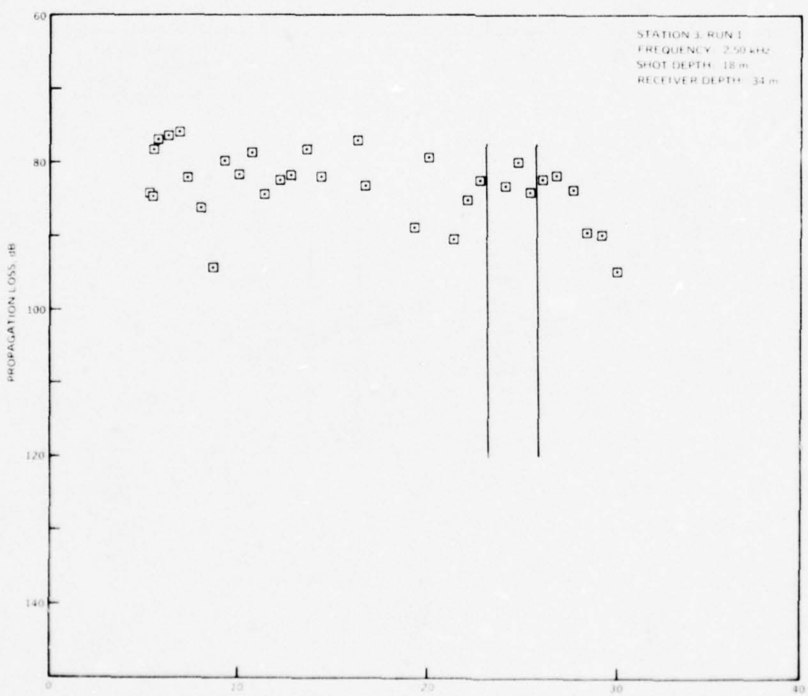

STATION 3, RUN 1
FREQUENCY: 1.60 kHz
SHOT DEPTH: 18 m
RECEIVER DEPTH: 69 m
PROPAGATION LOSS, dB
60
80
100
120
140
0
10
20
30
40
RANGE, kyd

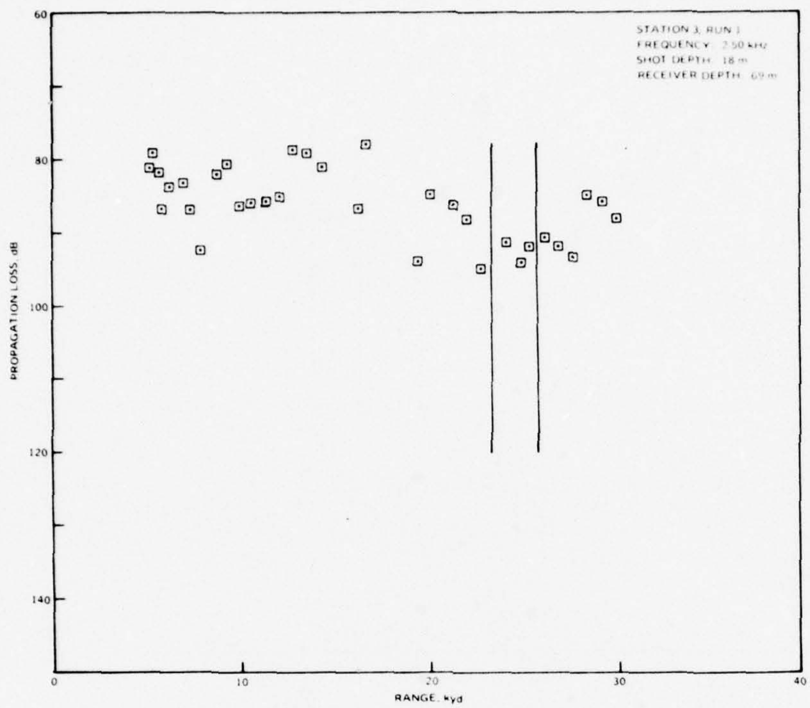

STATION 3, RUN 1
FREQUENCY: 1.60 kHz
SHOT DEPTH: 18 m
RECEIVER DEPTH: 112 m
PROPAGATION LOSS, dB
60
80
100
120
140
0
10
20
30
40
RANGE, kyd



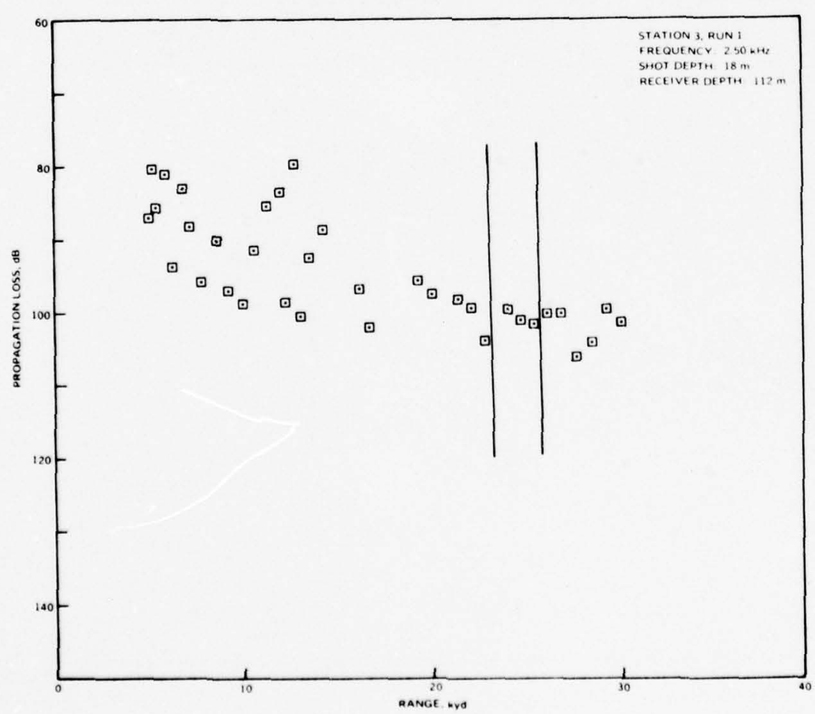
STATION 3, RUN 1
FREQUENCY 1.60 kHz
SHOT DEPTH 18 m
RECEIVER DEPTH 173 m
60
80
100
120
140
PROPAGATION LOSS, dB
0
10
20
30
40
RANGE, kyd


STATION 3, RUN 1
FREQUENCY 2.50 kHz
SHOT DEPTH 18 m
RECEIVER DEPTH 6 m
PROPAGATION LOSS, dB
RANGE, kyd
60
80
100
120
140
0
10
20
30
40

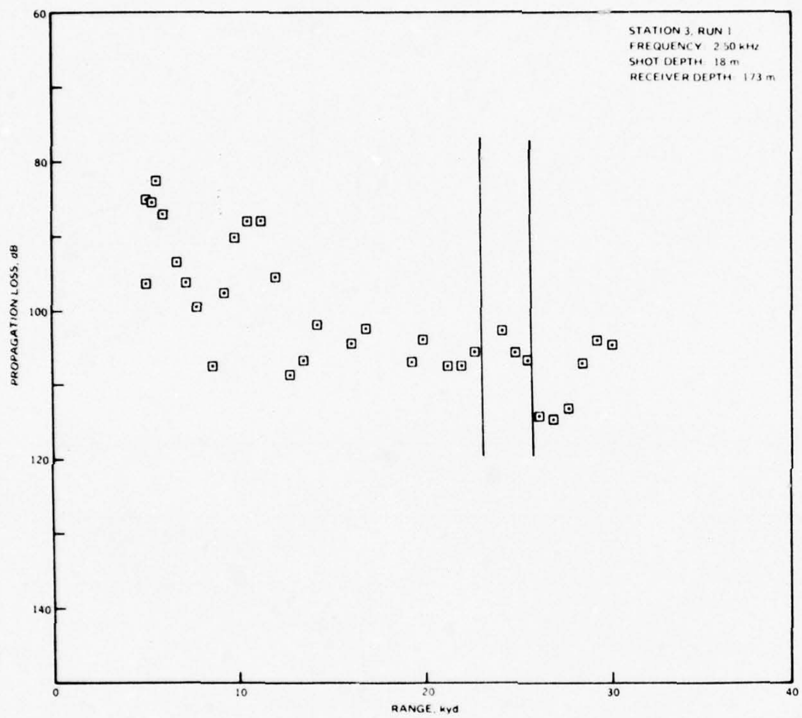

STATION 3, RUN 1
FREQUENCY 2.50 kHz
SHOT DEPTH 18 m
RECEIVER DEPTH 34 m
PROPAGATION LOSS, dB
RANGE, kyd
60
80
100
120
140
0
10
20
30
40

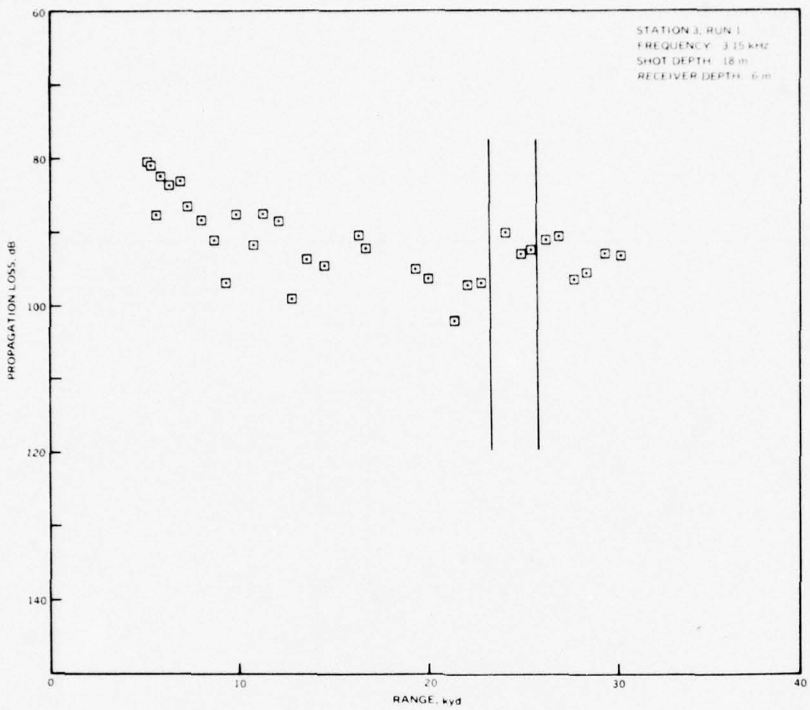


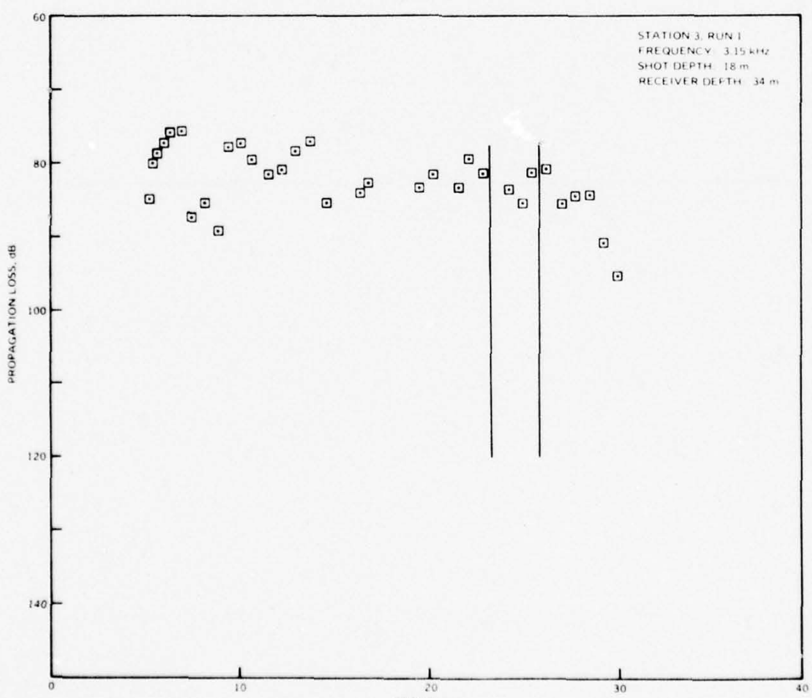
STATION 3, RUN 1
FREQUENCY: 2.50 kHz
SHOT DEPTH: 18 m
RECEIVER DEPTH: 69 m
PROPAGATION LOSS, dB
60
80
100
120
140
0
10
20
30
40
RANGE, kyd

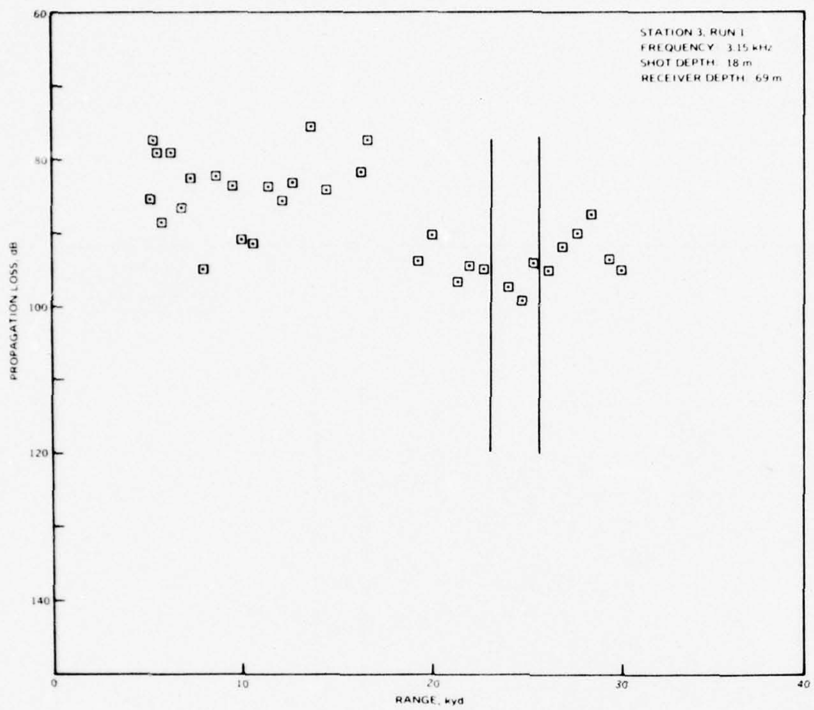


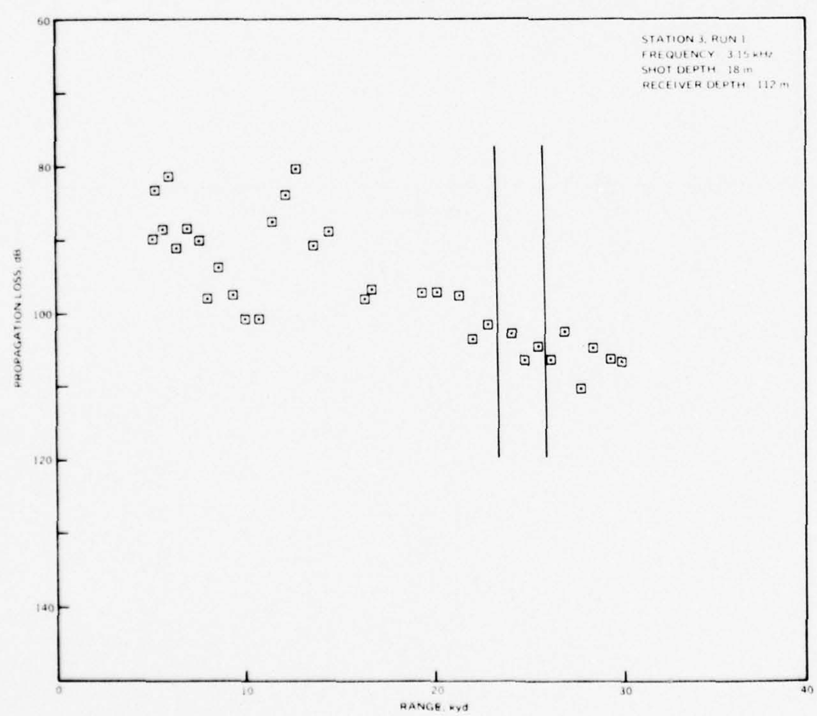
STATION 3, RUN 1
FREQUENCY: 2.50 kHz
SHOT DEPTH: 18 m
RECEIVER DEPTH: 112 m
PROPAGATION LOSS, dB
60
80
100
120
140
0
10
20
30
40
RANGE, kyd

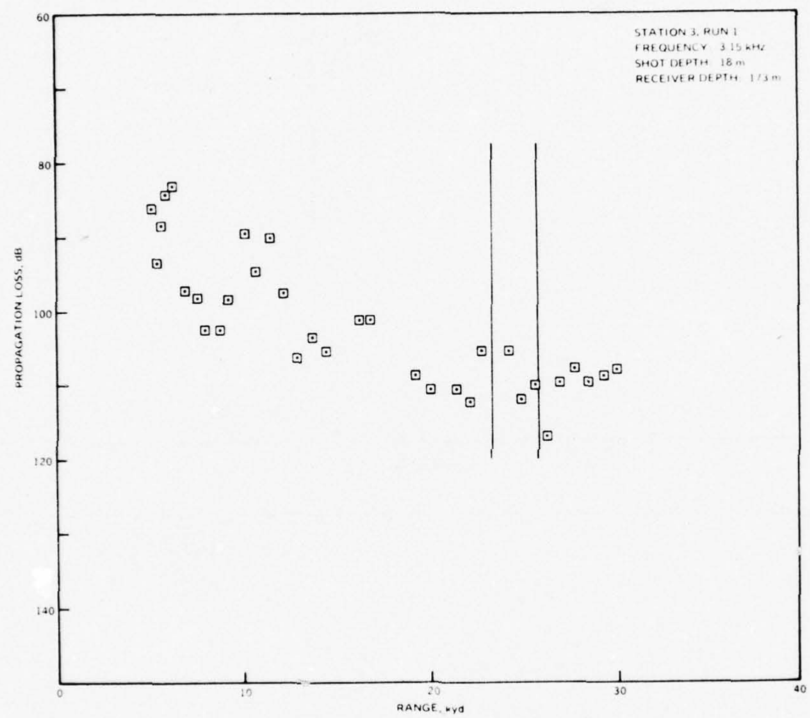

STATION 3, RUN 1
FREQUENCY: 2.50 kHz
SHOT DEPTH: 18 m
RECEIVER DEPTH: 173 m
PROPAGATION LOSS, dB
60
80
100
120
140
RANGE, kyd
0
10
20
30
40


STATION 3, RUN 1
FREQUENCY: 3.15 kHz
SHOT DEPTH: 18 m
RECEIVER DEPTH: 6 m
PROPAGATION LOSS, dB
60
80
100
120
140
RANGE, kyd
0
10
20
30
40

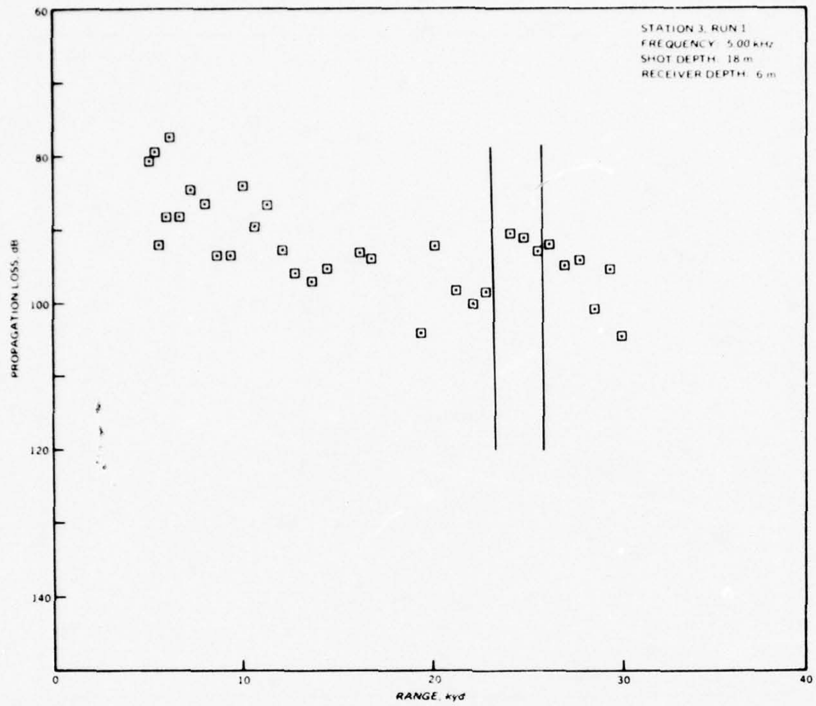

STATION 3, RUN 1
FREQUENCY: 3.15 kHz
SHOT DEPTH: 18 m
RECEIVER DEPTH: 34 m
PROPAGATION LOSS, dB
60
80
100
120
140
RANGE, kyd
0
10
20
30
40

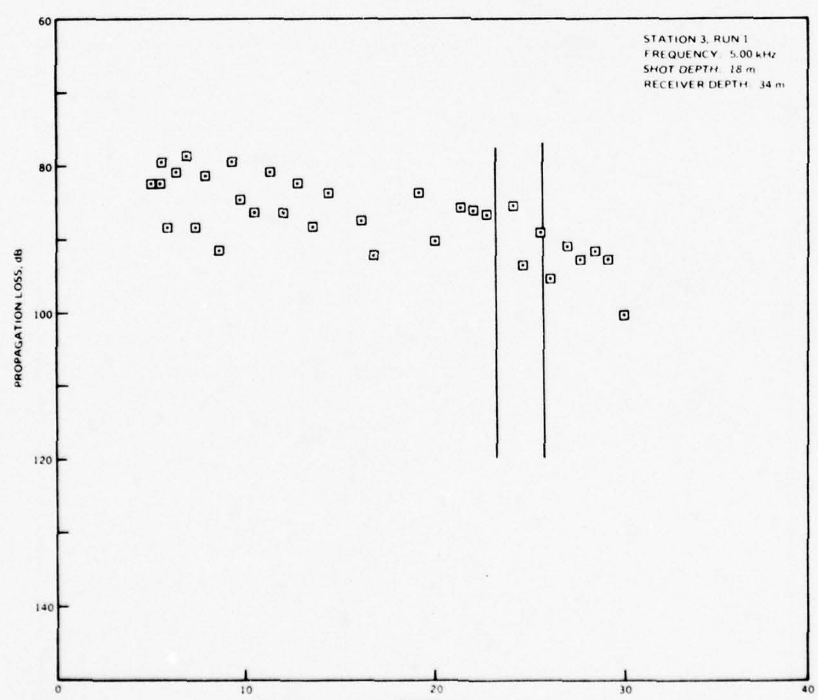

STATION 3, RUN 1
FREQUENCY 3.15 kHz
SHOT DEPTH 18 m
RECEIVER DEPTH 69 m
PROPAGATION LOSS, dB
60
80
100
120
140
0
10
20
30
40
RANGE, kyd

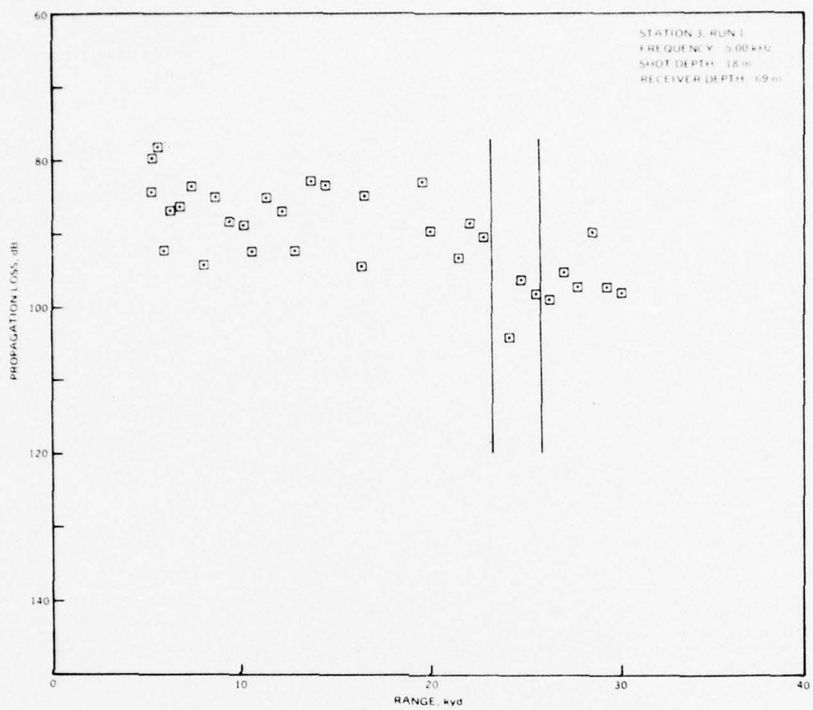

STATION 3, RUN 1
FREQUENCY 3.15 kHz
SHOT DEPTH 18 m
RECEIVER DEPTH 112 m
PROPAGATION LOSS, dB
60
80
100
120
140
0
10
20
30
40
RANGE, kyd

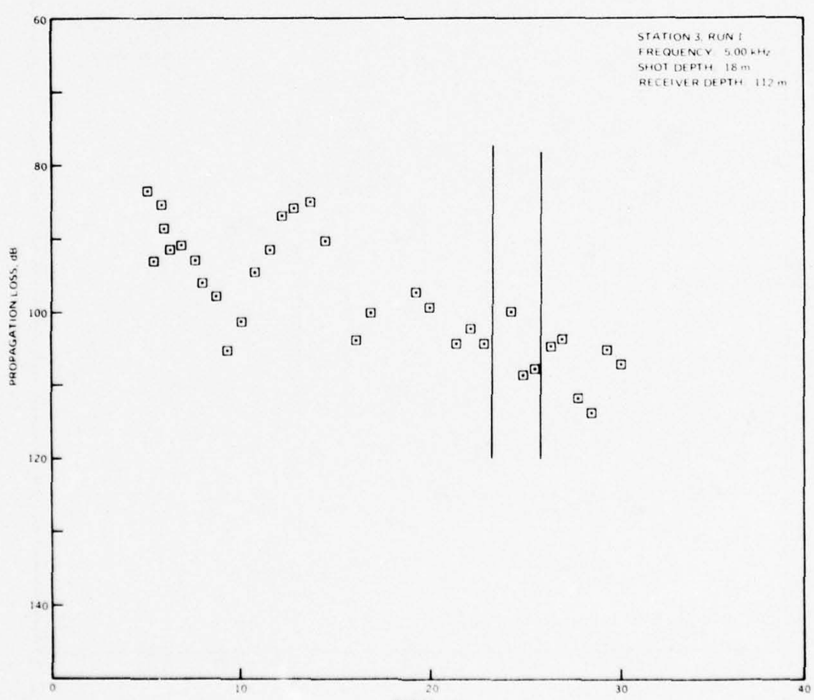


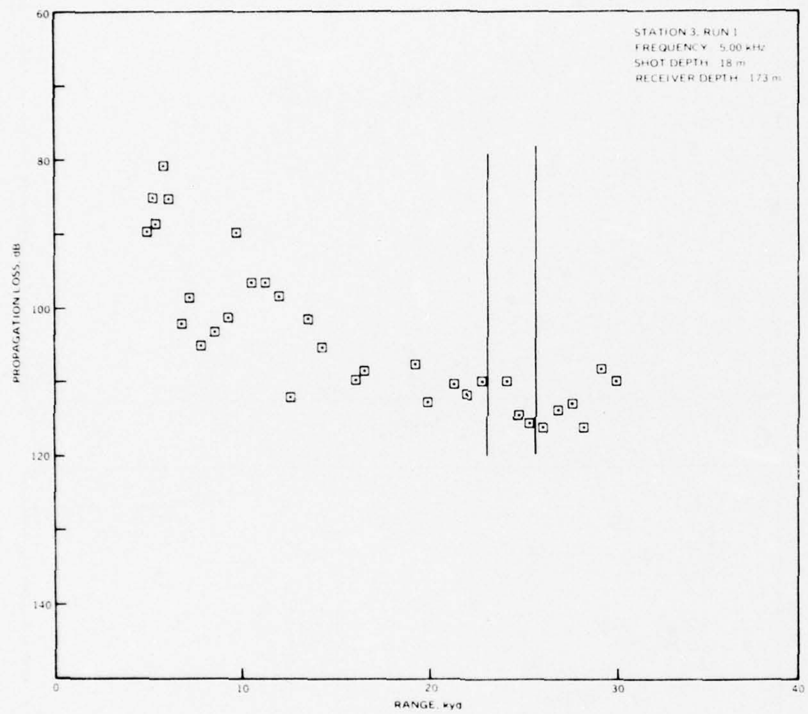
STATION 3, RUN 1
FREQUENCY: 3.15 kHz
SHOT DEPTH: 18 m
RECEIVER DEPTH: 173 m
PROPAGATION LOSS, dB
60
80
100
120
140
RANGE, kyd
0
10
20
30
40

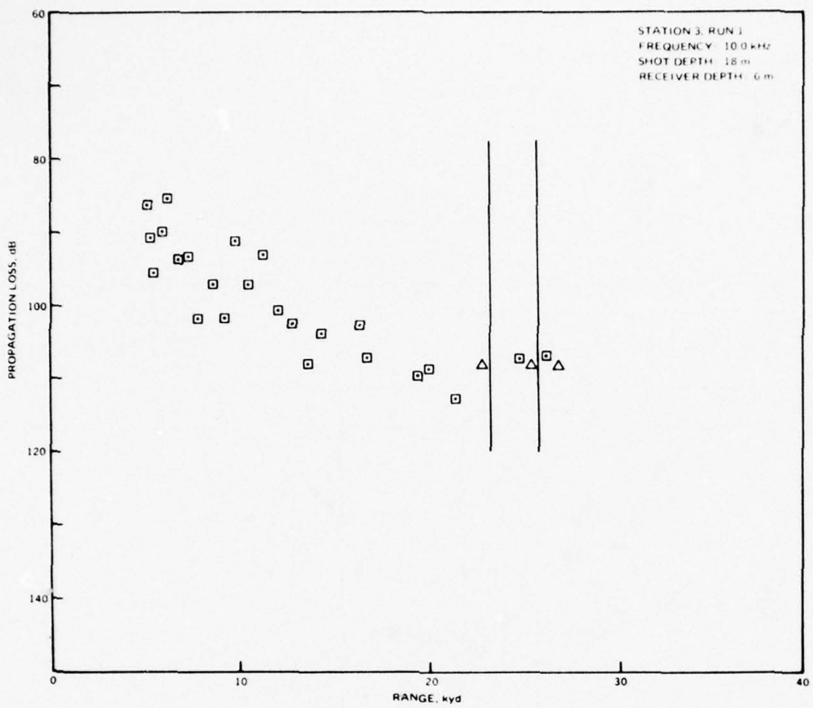

STATION 3, RUN 1
FREQUENCY: 5.00 kHz
SHOT DEPTH: 18 m
RECEIVER DEPTH: 6 m
PROPAGATION LOSS, dB
RANGE, kyd

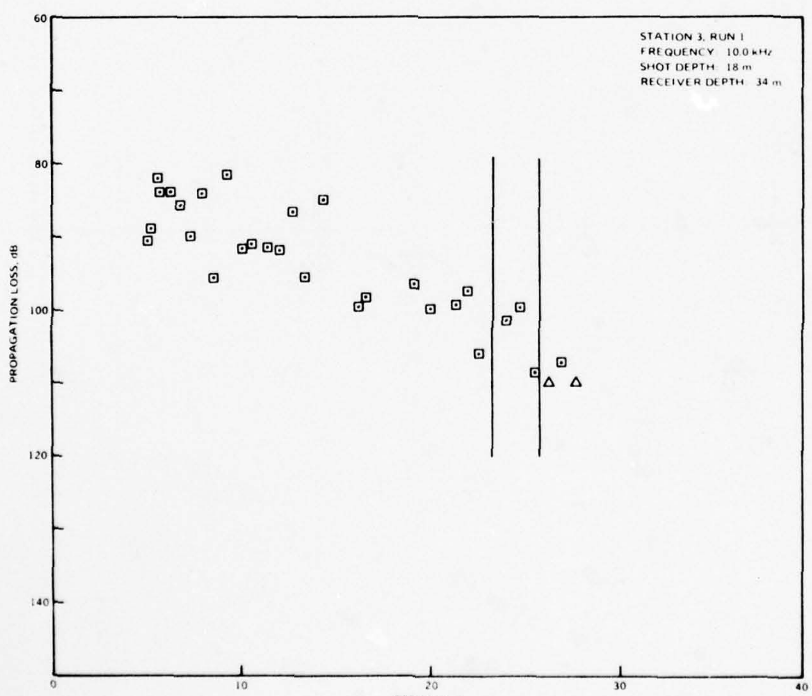

STATION 3, RUN 1
FREQUENCY: 5.00 kHz
SHOT DEPTH: 18 m
RECEIVER DEPTH: 34 m
PROPAGATION LOSS, dB
RANGE, kyd

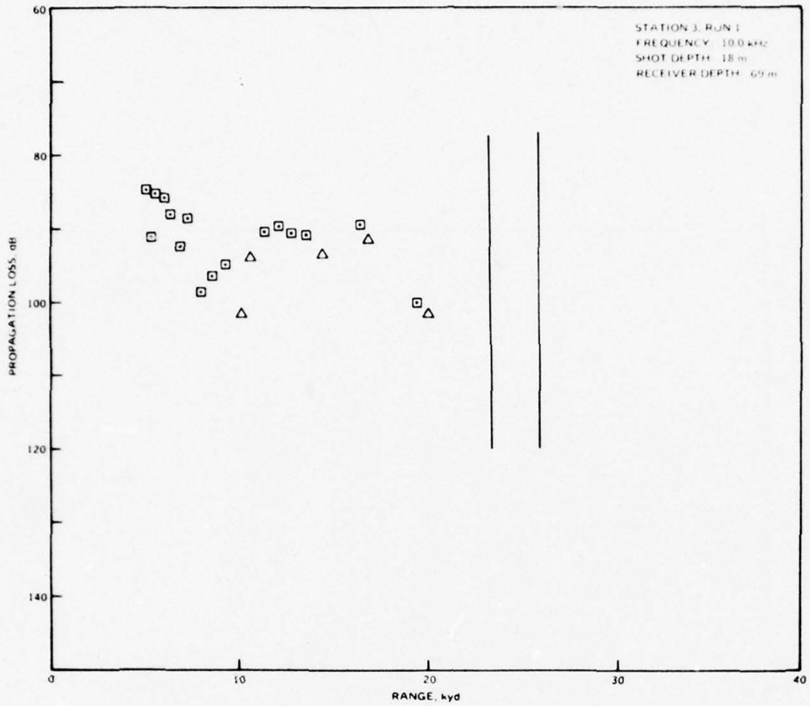

STATION 3, RUN I
FREQUENCY 5.00 kHz
SHOT DEPTH 18 m
RECEIVER DEPTH 69 m
PROPAGATION LOSS, dB
60
80
100
120
140
0
10
20
30
40
RANGE, kyd

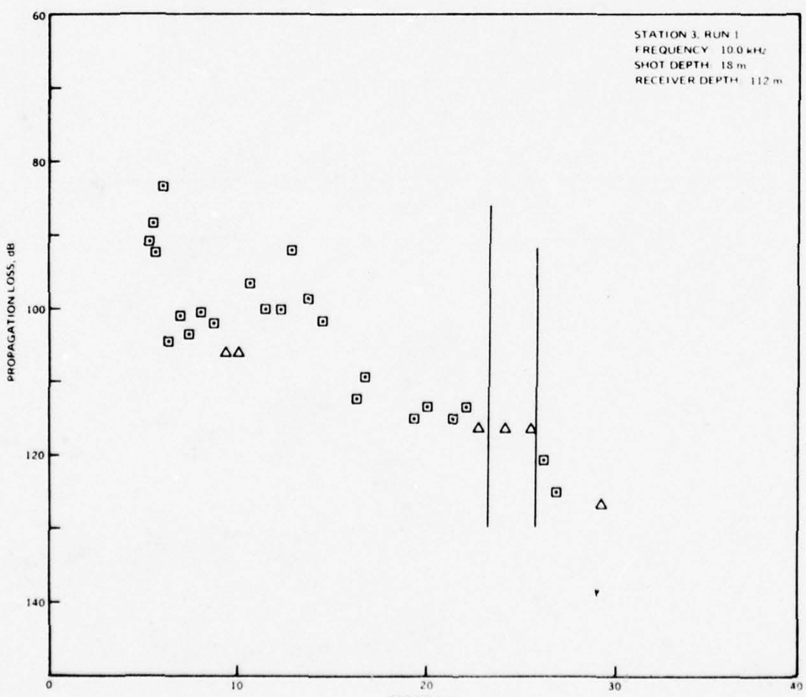

STATION 3, RUN I
FREQUENCY 5.00 kHz
SHOT DEPTH 18 m
RECEIVER DEPTH 112 m
PROPAGATION LOSS, dB
60
80
100
120
140
0
10
20
30
40
RANGE, kyd

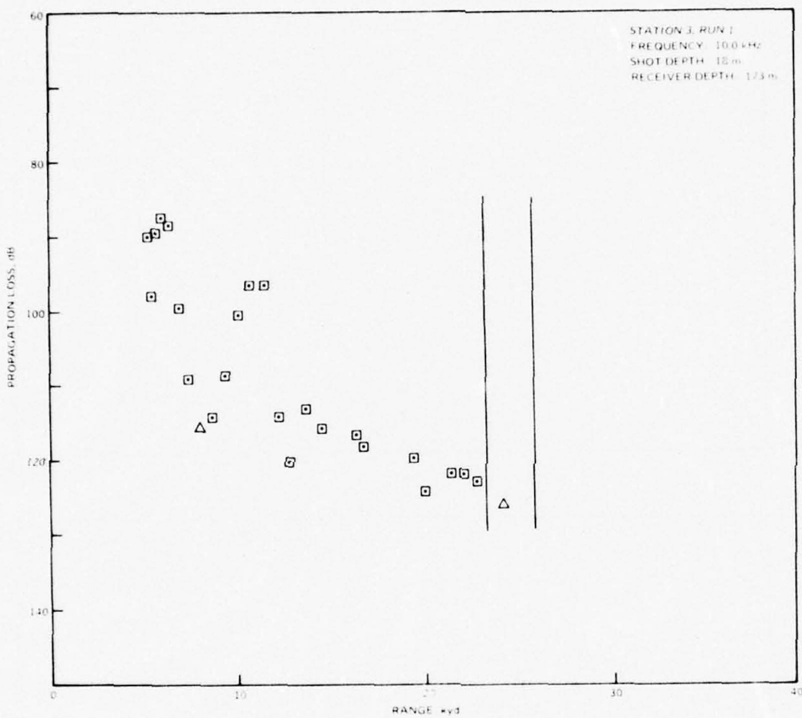

STATION 3, RUN 1
FREQUENCY 5.00 kHz
SHOT DEPTH 18 m
RECEIVER DEPTH 173 m
PROPAGATION LOSS, dB
60
80
100
120
140
0
10
20
30
40
RANGE, kyd


STATION 3, RUN 1
FREQUENCY: 10.0 kHz
SHOT DEPTH: 18 m
RECEIVER DEPTH: 6 m
PROPAGATION LOSS, dB
60
80
100
120
140
0
10
20
30
40
RANGE, kyd


STATION 3, RUN 1
FREQUENCY: 10.0 kHz
SHOT DEPTH: 18 m
RECEIVER DEPTH: 34 m
PROPAGATION LOSS, dB
60
80
100
120
140
0
10
20
30
40
RANGE, kyd


STATION 3, RUN 1
FREQUENCY 10.0 kHz
SHOT DEPTH 18 m
RECEIVER DEPTH 69 m
PROPAGATION LOSS, dB
60
80
100
120
140
0
10
20
30
40
RANGE, kyd


STATION 3, RUN 1
FREQUENCY 10.0 kHz
SHOT DEPTH 18 m
RECEIVER DEPTH 112 m
PROPAGATION LOSS, dB
60
80
100
120
140
0
10
20
30
40
RANGE, kyd

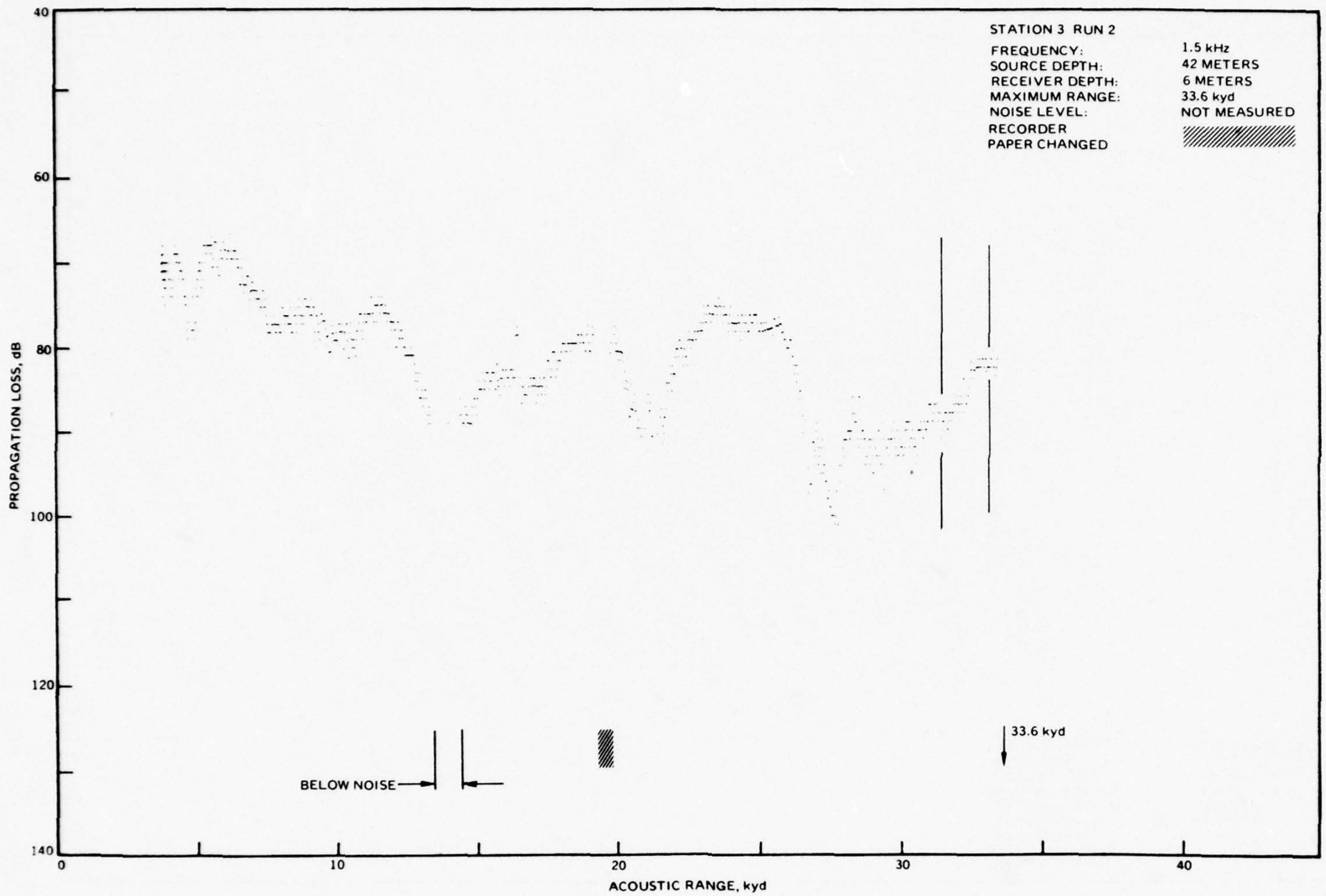


STATION 3, RUN 1
FREQUENCY 10.0 kHz
SHOT DEPTH 18 m
RECEIVER DEPTH 173 m
PROPAGATION LOSS, dB
60
80
100
120
140
0
10
20
30
40
RANGE, kyd

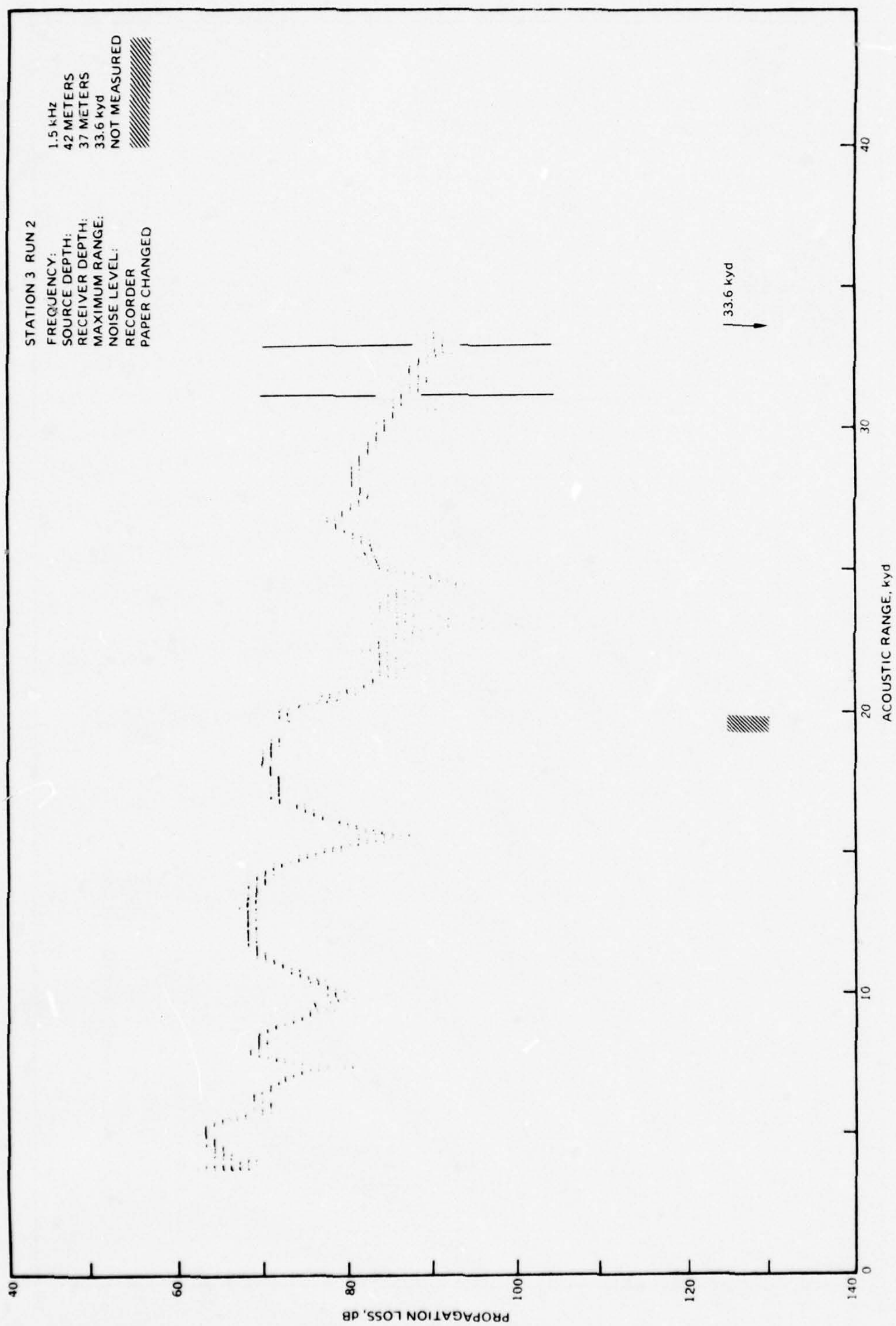
APPENDIX B

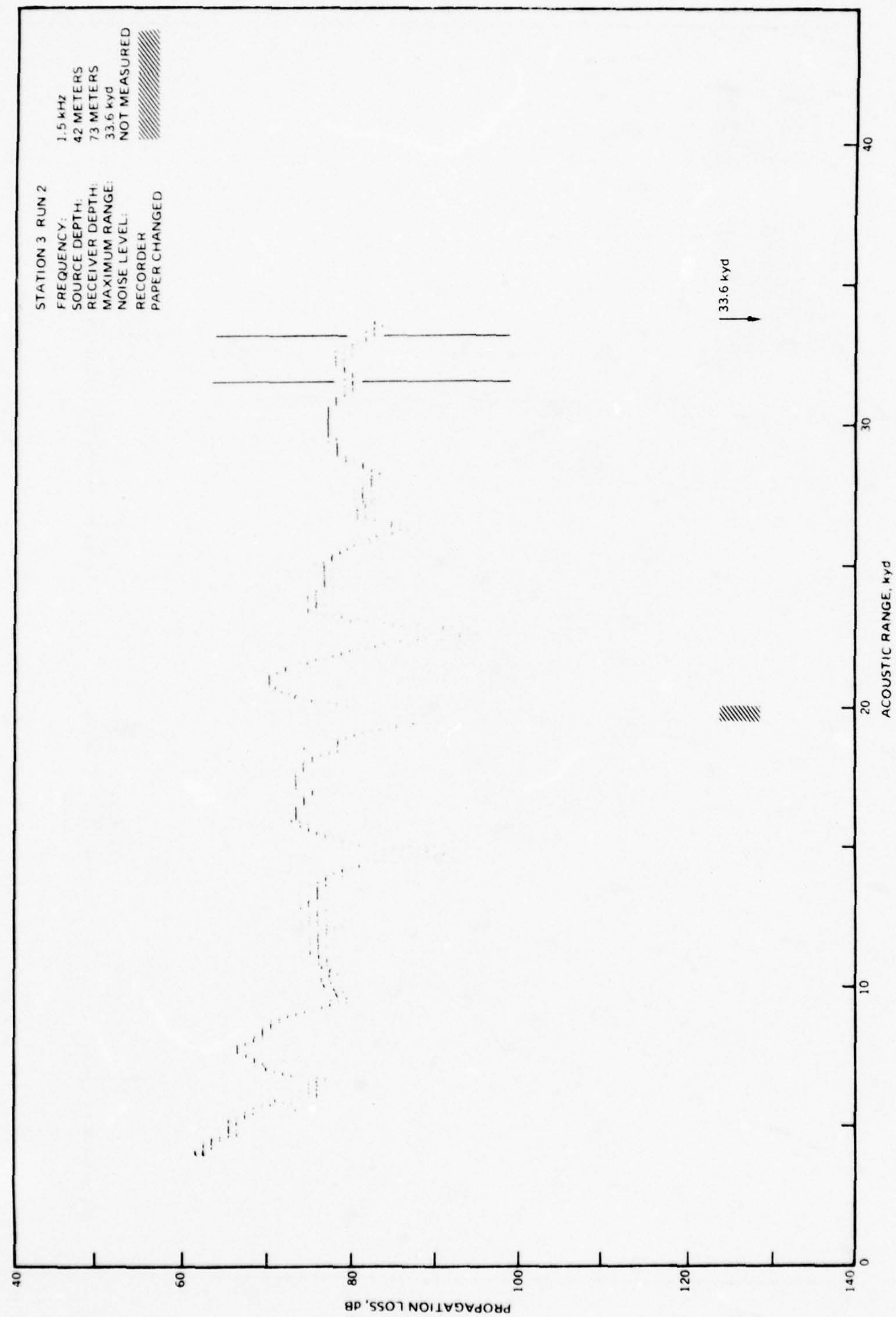
STATION 3 RUN 2

PROPAGATION LOSS VERSUS ACOUSTIC RANGE PLOTS

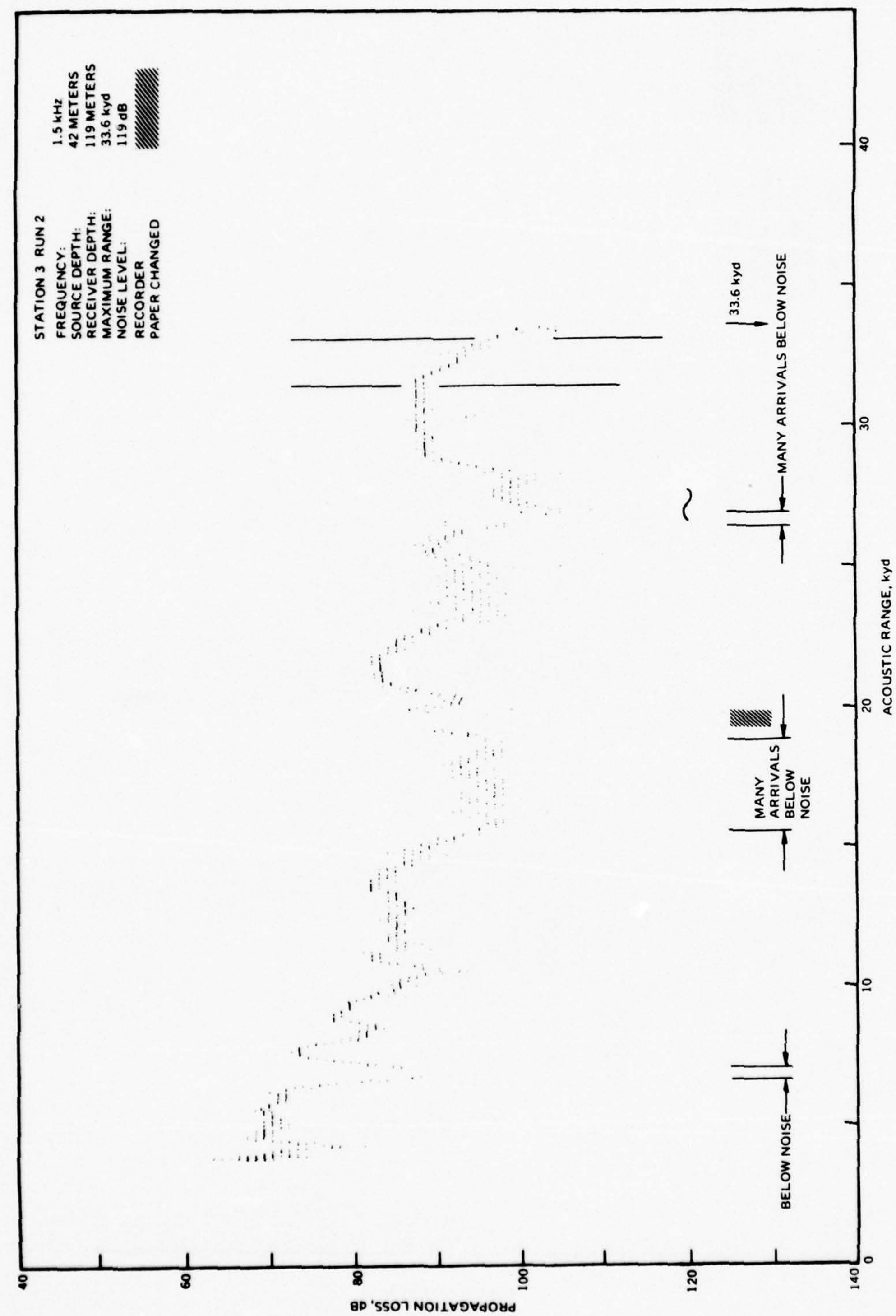


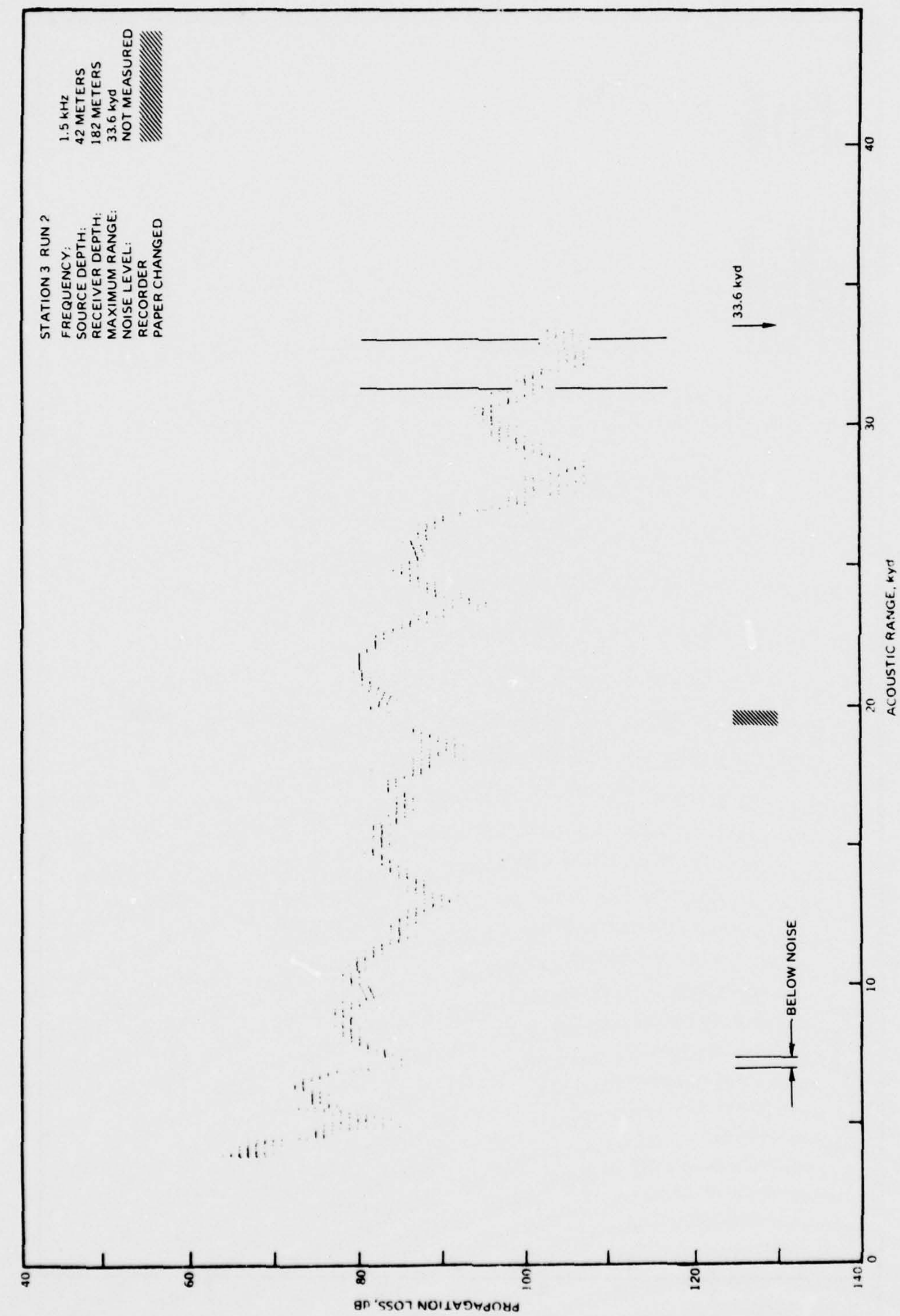
STATION 3 RUN 2
FREQUENCY: 1.5 kHz
SOURCE DEPTH: 42 METERS
RECEIVER DEPTH: 6 METERS
MAXIMUM RANGE: 33.6 kyd
NOISE LEVEL: NOT MEASURED
RECORDER PAPER CHANGED
BELOW NOISE
33.6 kyd
PROPAGATION LOSS, dB
40
60
80
100
120
140
0
10
20
30
40
ACOUSTIC RANGE, kyd

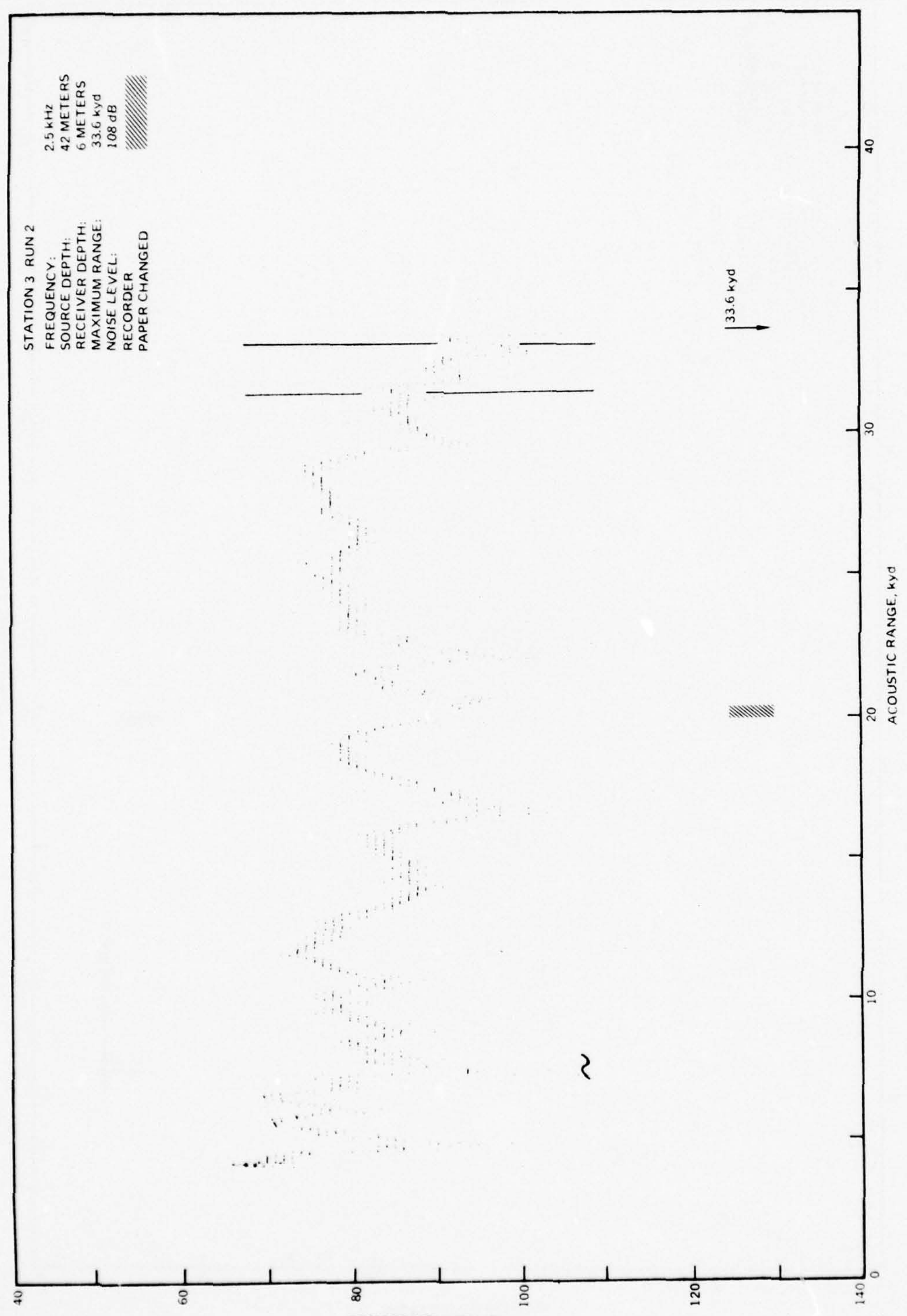

STATION 3 RUN 2
FREQUENCY: 1.5 kHz
SOURCE DEPTH: 42 METERS
RECEIVER DEPTH: 37 METERS
MAXIMUM RANGE: 33.6 kyd
NOISE LEVEL: NOT MEASURED
RECORDER PAPER CHANGED
33.6 kyd
PROPAGATION LOSS, dB
40
60
80
100
120
140
0
10
20
30
40
ACOUSTIC RANGE, kyd



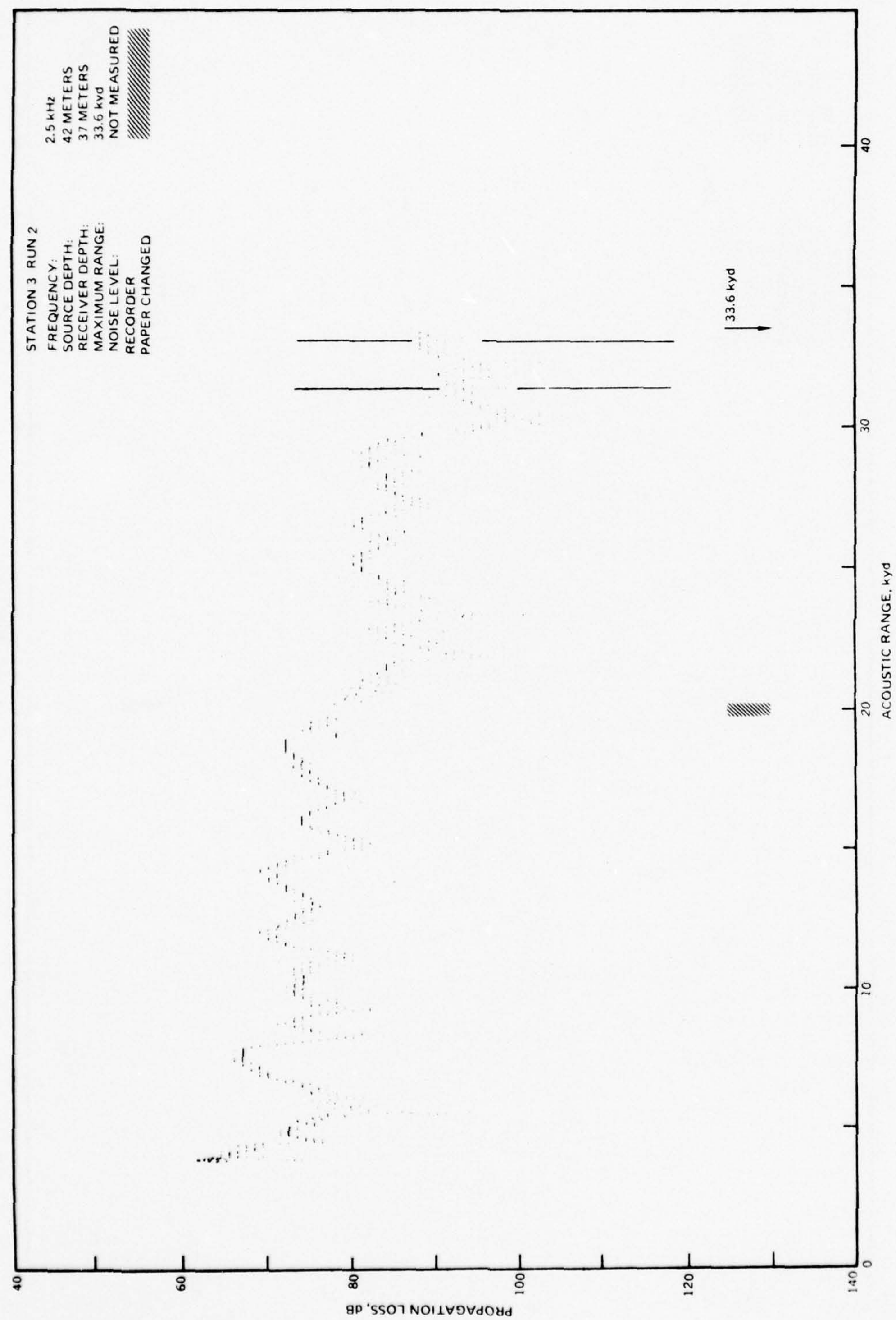
STATION 3 RUN 2
FREQUENCY: 1.5 kHz
SOURCE DEPTH: 42 METERS
RECEIVER DEPTH: 73 METERS
MAXIMUM RANGE: 33.6 kyd
NOISE LEVEL: NOT MEASURED
RECORDER PAPER CHANGED
33.6 kyd
PROPAGATION LOSS, dB
40
60
80
100
120
140
ACOUSTIC RANGE, kyd
0
10
20
30
40

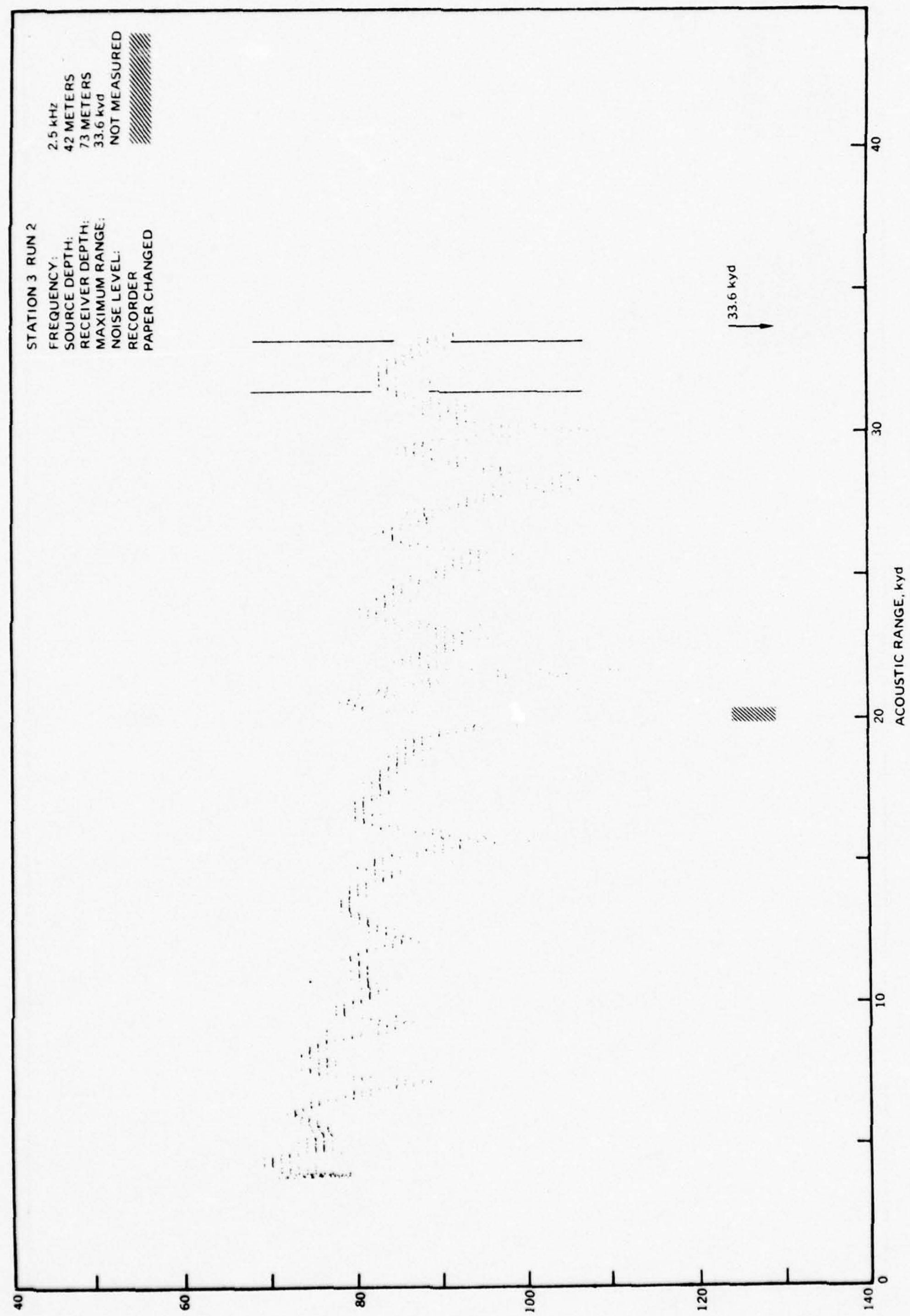

STATION 3 RUN 2
FREQUENCY: 1.5 kHz
SOURCE DEPTH: 42 METERS
RECEIVER DEPTH: 119 METERS
MAXIMUM RANGE: 33.6 kyd
NOISE LEVEL: 119 dB
RECORDER PAPER CHANGED
BELOW NOISE
MANY ARRIVALS BELOW NOISE
MANY ARRIVALS BELOW NOISE
33.6 kyd
PROPAGATION LOSS, dB
40
60
80
100
120
140
ACOUSTIC RANGE, kyd
0
10
20
30
40

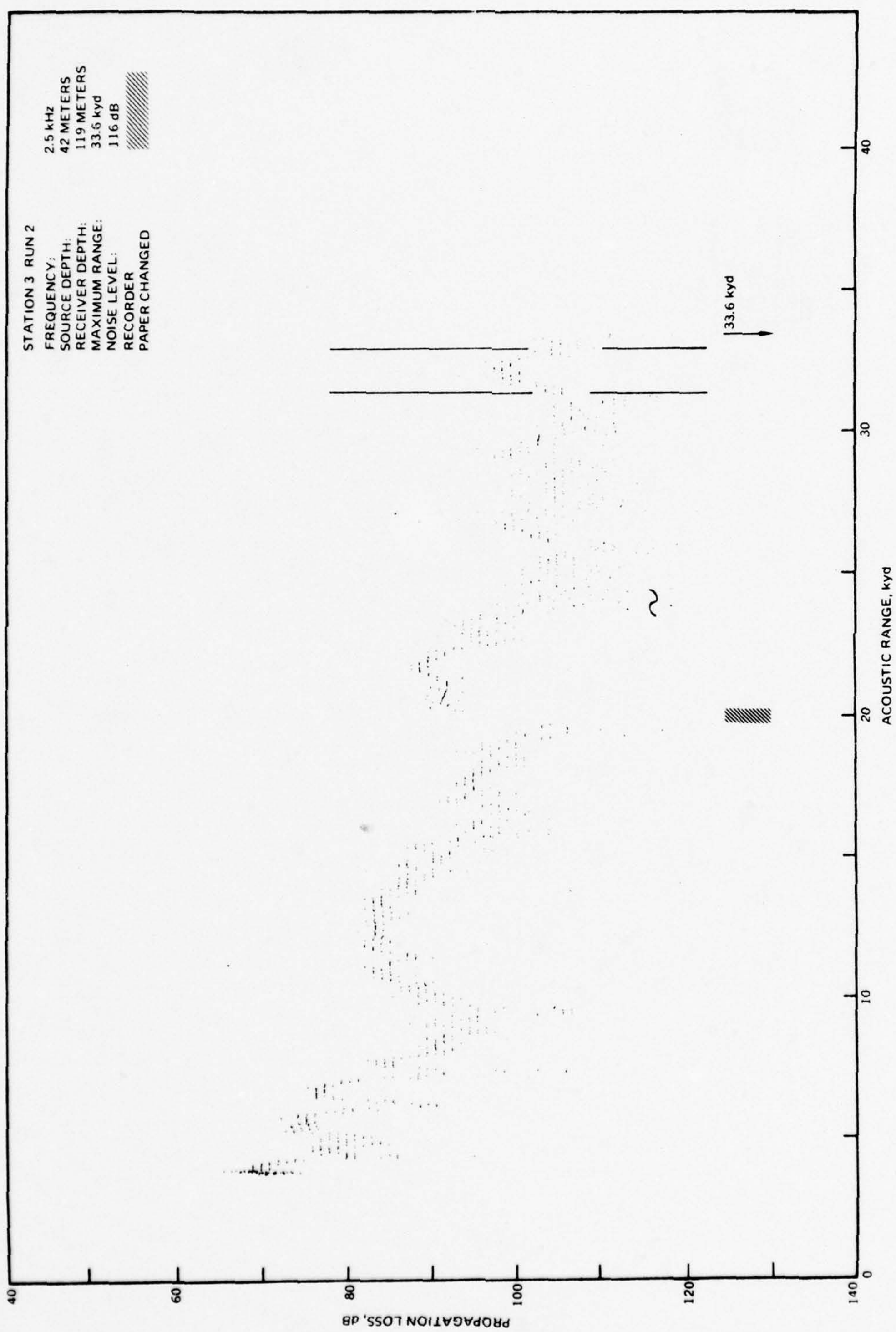

STATION 3 RUN 2
FREQUENCY: 1.5 kHz
SOURCE DEPTH: 42 METERS
RECEIVER DEPTH: 182 METERS
MAXIMUM RANGE: 33.6 kyd
NOISE LEVEL: NOT MEASURED
RECORDER PAPER CHANGED
33.6 kyd
BELOW NOISE
ACOUSTIC RANGE, kyd
0
10
20
30
40
PROPAGATION LOSS, dB
40
60
80
100
120
140

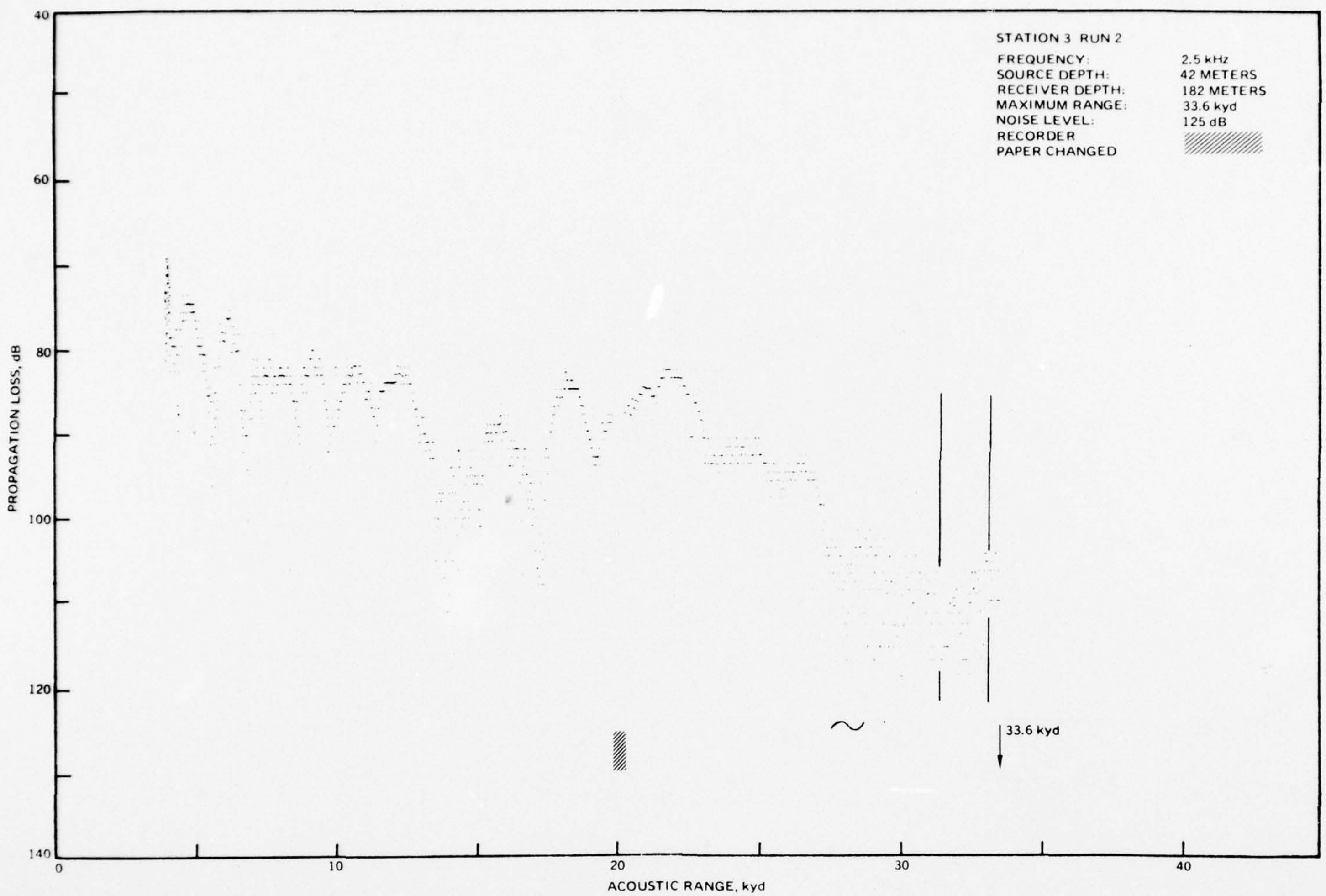


STATION 3 RUN 2
FREQUENCY: 2.5 kHz
SOURCE DEPTH: 42 METERS
RECEIVER DEPTH: 6 METERS
MAXIMUM RANGE: 33.6 kyd
NOISE LEVEL: 108 dB
RECORDER PAPER CHANGED
33.6 kyd
PROPAGATION LOSS, dB
40
60
80
100
120
140
ACOUSTIC RANGE, kyd
0
10
20
30
40


STATION 3 RUN 2
FREQUENCY: 2.5 kHz
SOURCE DEPTH: 42 METERS
RECEIVER DEPTH: 37 METERS
MAXIMUM RANGE: 33.6 kyd
NOISE LEVEL: NOT MEASURED
RECORDER PAPER CHANGED
33.6 kyd
ACOUSTIC RANGE, kyd
PROPAGATION LOSS, dB
0
10
20
30
40
40
60
80
100
120
140


STATION 3 RUN 2
FREQUENCY: 2.5 kHz
SOURCE DEPTH: 42 METERS
RECEIVER DEPTH: 73 METERS
MAXIMUM RANGE: 33.6 kyd
NOISE LEVEL: NOT MEASURED
RECORDER
PAPER CHANGED
33.6 kyd
PROPAGATION LOSS, dB
40
60
80
100
120
140
ACOUSTIC RANGE, kyd
0
10
20
30
40

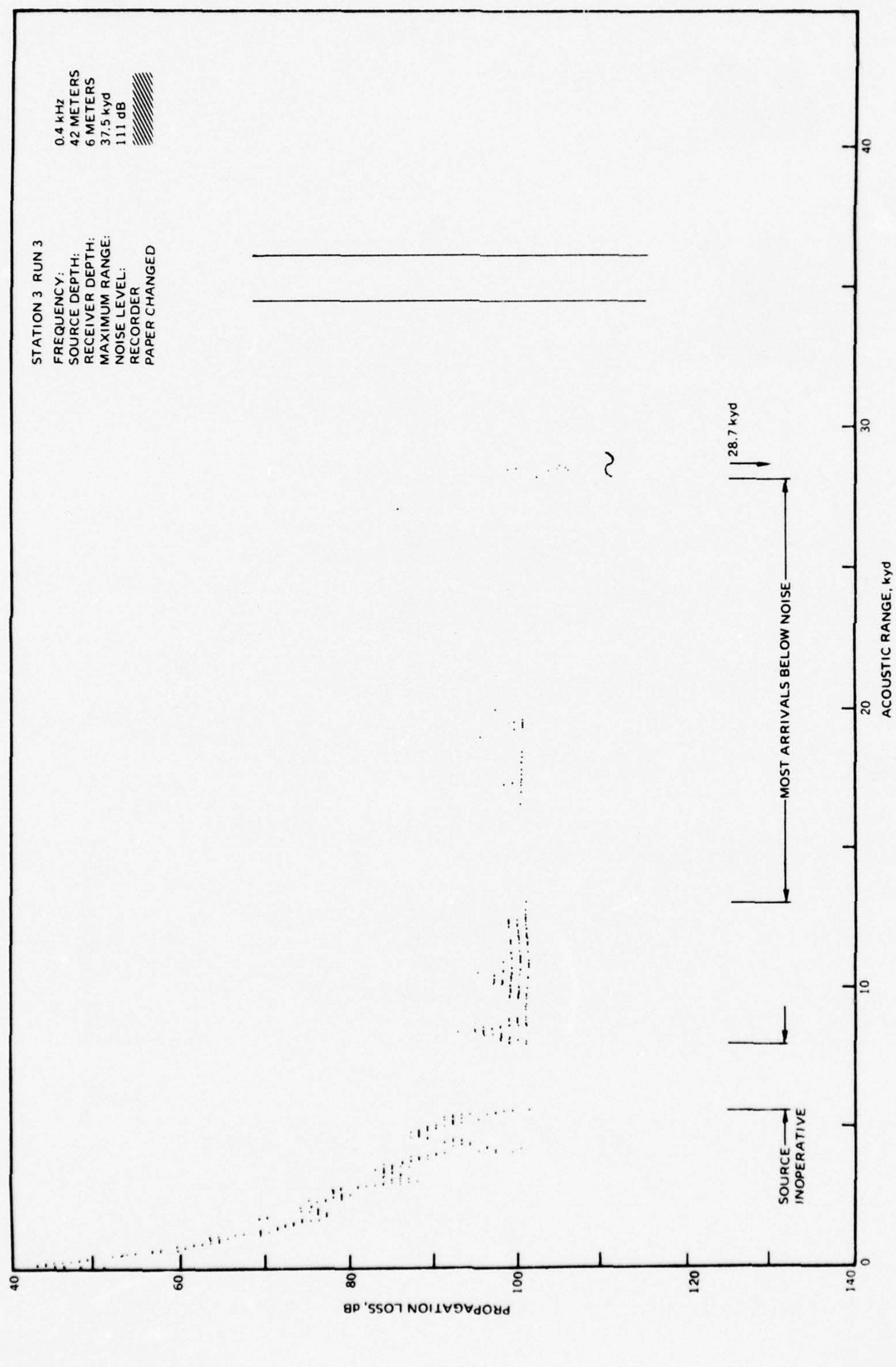

STATION 3 RUN 2
FREQUENCY: 2.5 kHz
SOURCE DEPTH: 42 METERS
RECEIVER DEPTH: 119 METERS
MAXIMUM RANGE: 33.6 kyd
NOISE LEVEL: 116 dB
RECORDER PAPER CHANGED
33.6 kyd
PROPAGATION LOSS, dB
40
60
80
100
120
140
ACOUSTIC RANGE, kyd
0
10
20
30
40

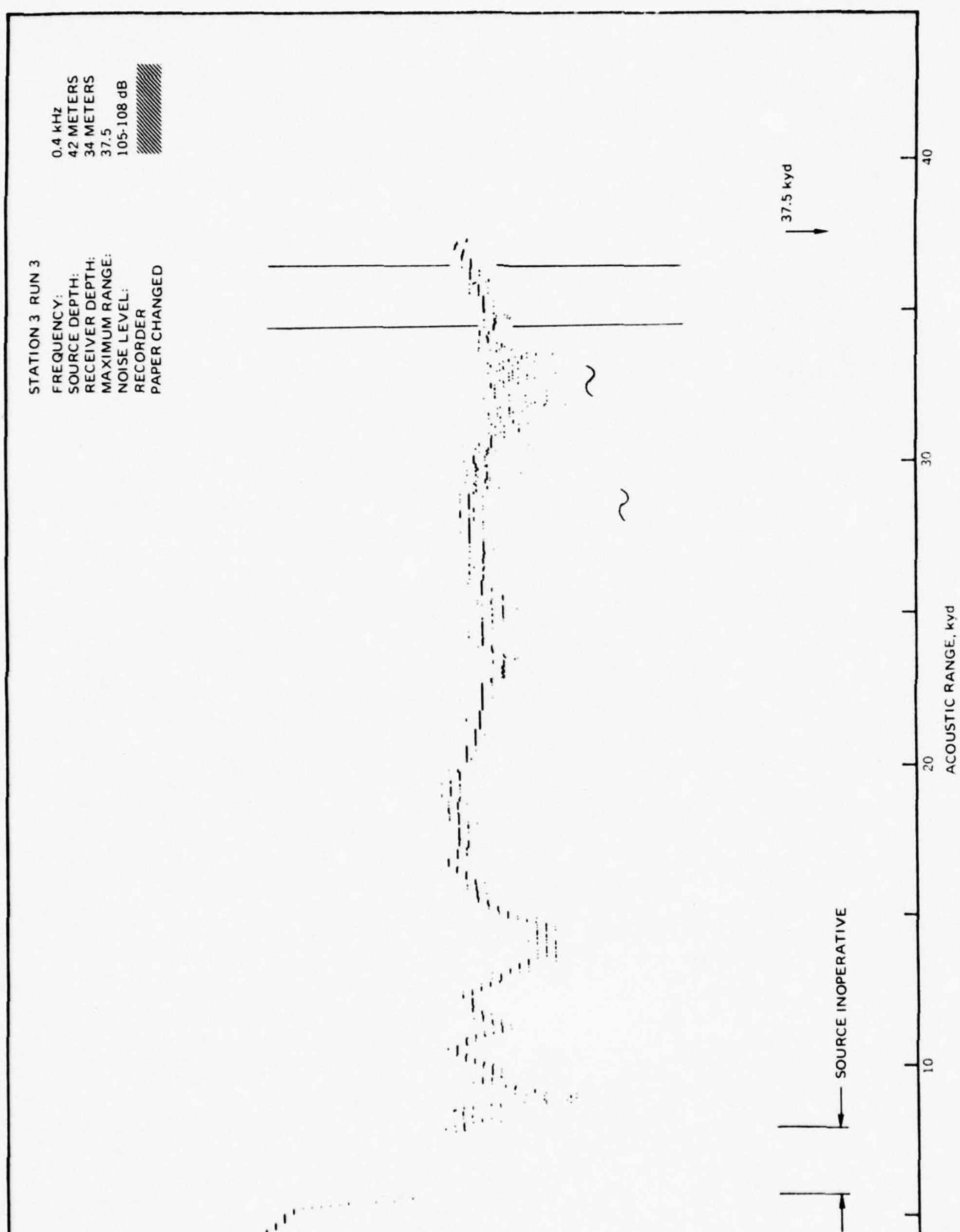

STATION 3 RUN 2
FREQUENCY: 2.5 kHz
SOURCE DEPTH: 42 METERS
RECEIVER DEPTH: 182 METERS
MAXIMUM RANGE: 33.6 kyd
NOISE LEVEL: 125 dB
RECORDER PAPER CHANGED
33.6 kyd
PROPAGATION LOSS, dB
40
60
80
100
120
140
0
10
20
30
40
ACOUSTIC RANGE, kyd

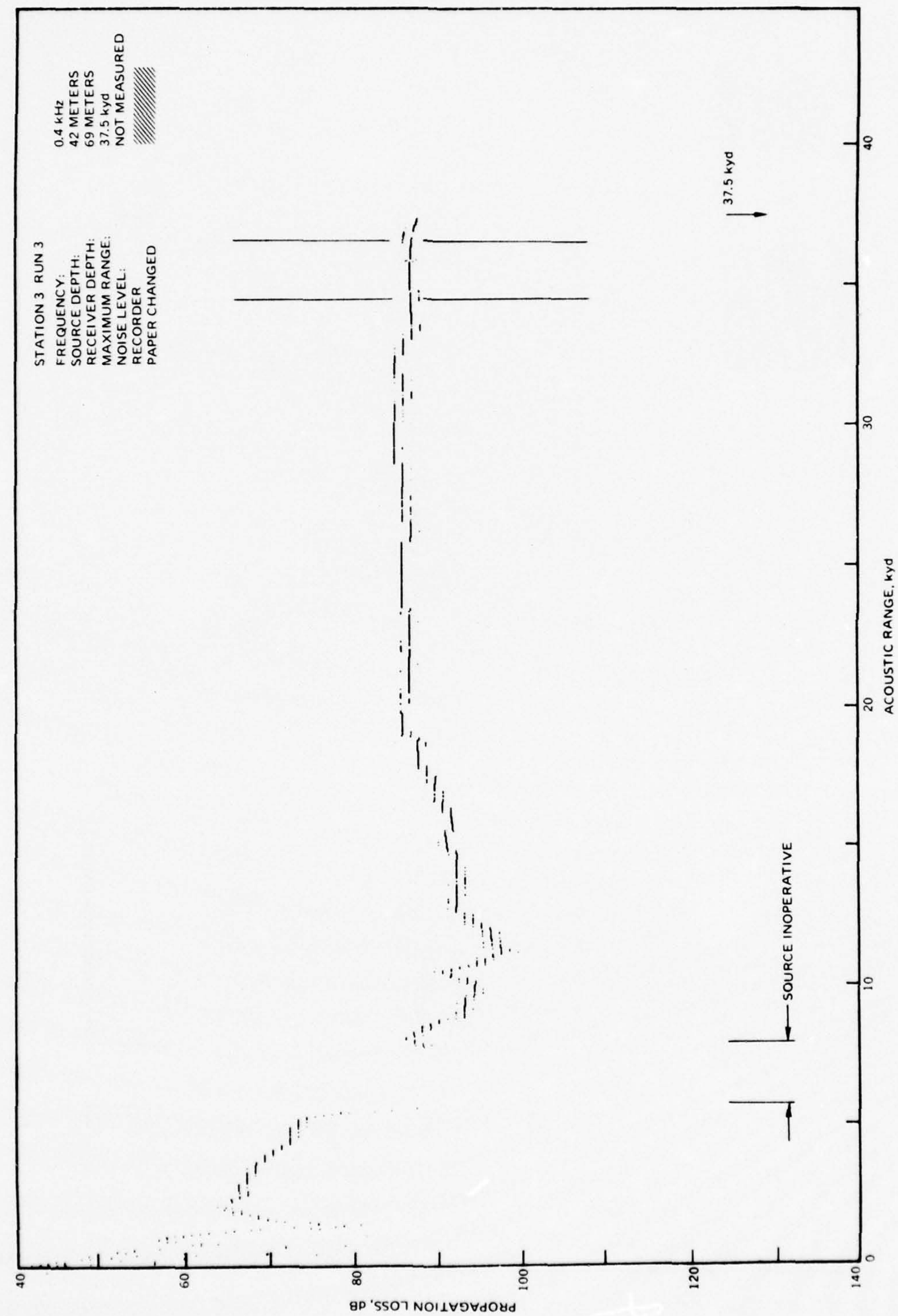
APPENDIX C

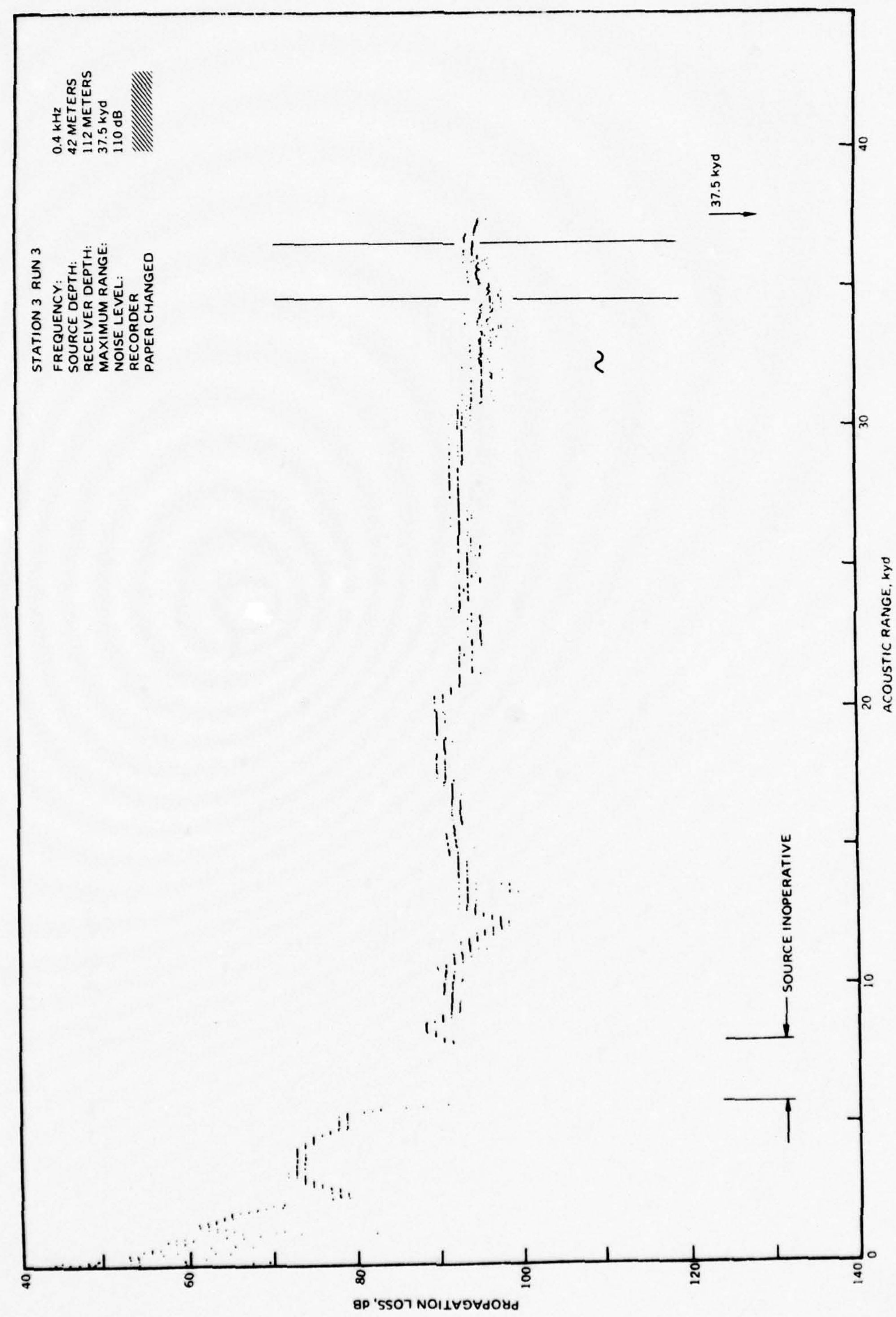
STATION 3 RUN 3

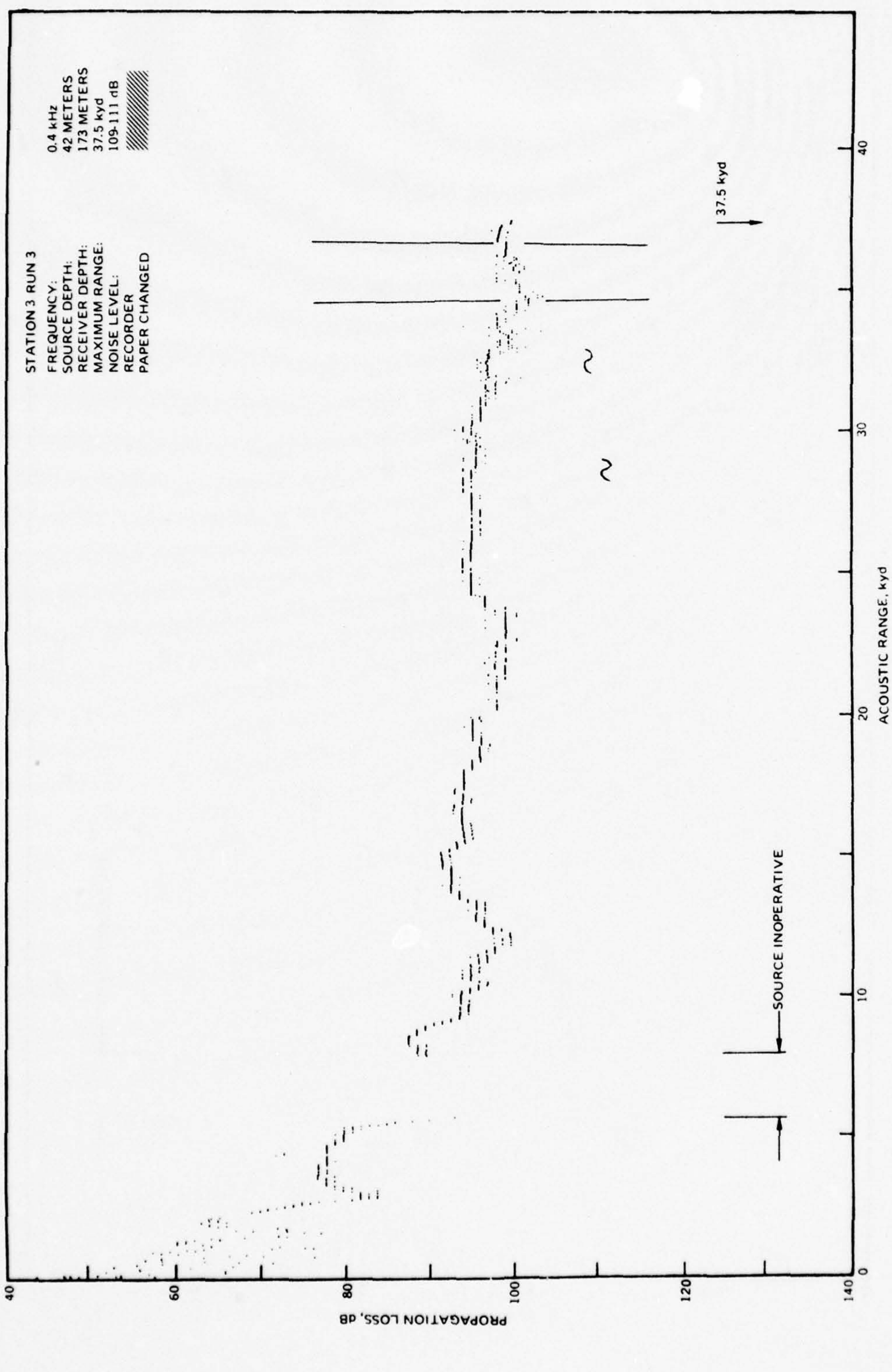
PROPAGATION LOSS VERSUS ACOUSTIC RANGE PLOTS


STATION 3 RUN 3
FREQUENCY: 0.4 kHz
SOURCE DEPTH: 42 METERS
RECEIVER DEPTH: 6 METERS
MAXIMUM RANGE: 37.5 kyd
NOISE LEVEL: 111 dB
RECORDER PAPER CHANGED
28.7 kyd
MOST ARRIVALS BELOW NOISE
SOURCE INOPERATIVE
PROPAGATION LOSS, dB
40
60
80
100
120
140
0
10
20
30
40
ACOUSTIC RANGE, kyd

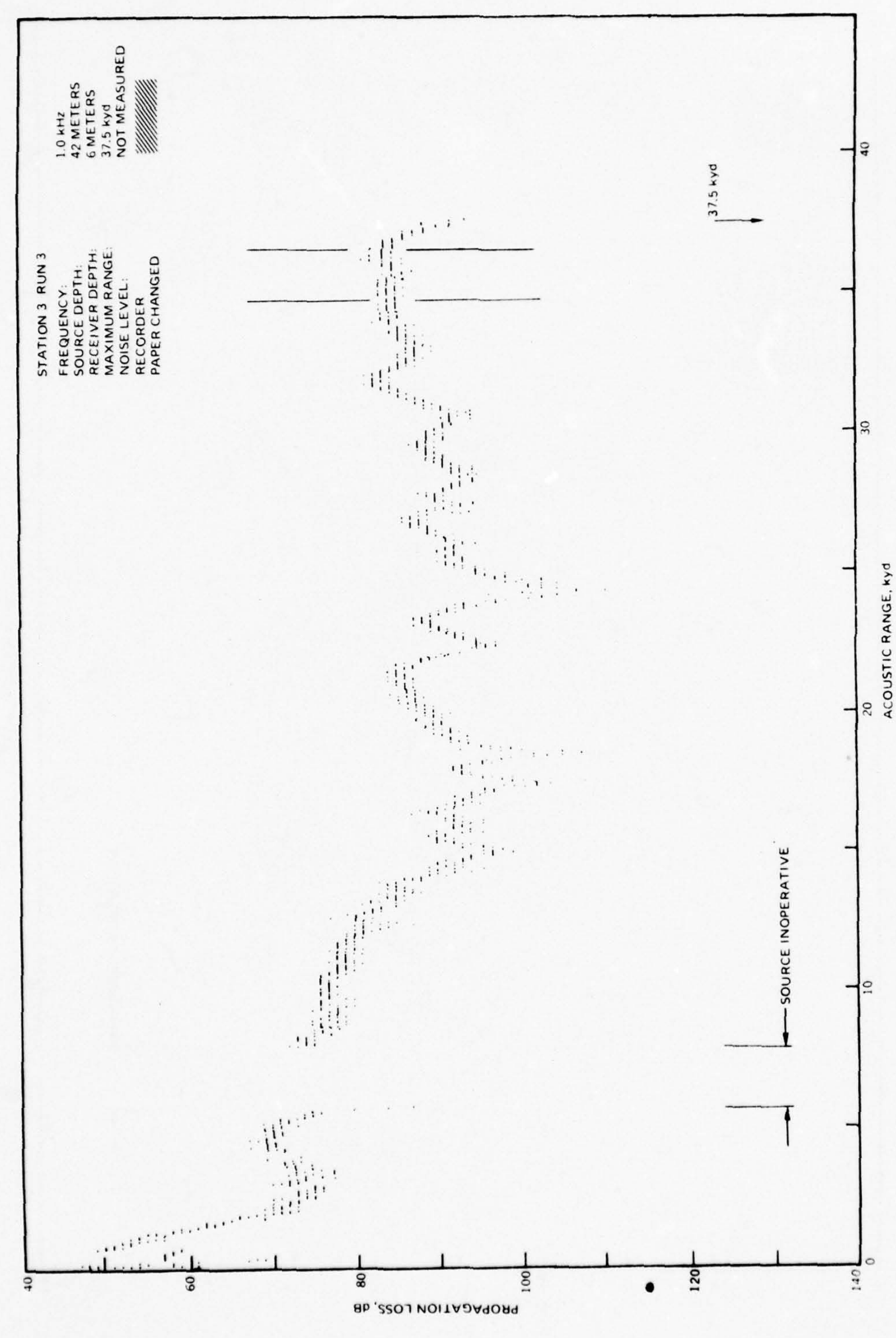

STATION 3 RUN 3
FREQUENCY: 0.4 kHz
SOURCE DEPTH: 42 METERS
RECEIVER DEPTH: 34 METERS
MAXIMUM RANGE: 37.5
NOISE LEVEL: 105-108 dB
RECORDER PAPER CHANGED
37.5 kyd
SOURCE INOPERATIVE
ACOUSTIC RANGE, kyd
PROPAGATION LOSS, dB
0
10
20
30
40
60
80
100
120
140

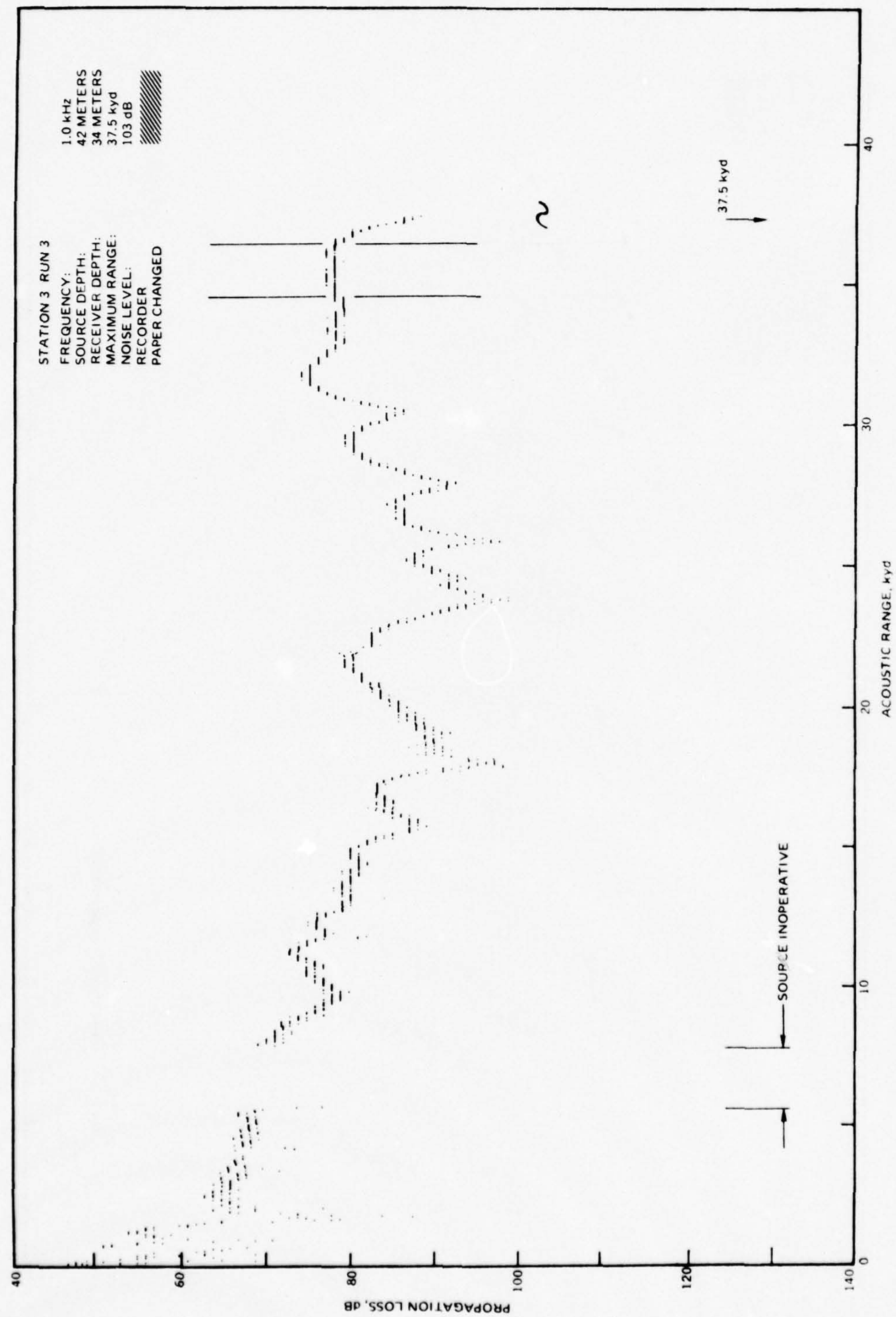

STATION 3 RUN 3
FREQUENCY: 0.4 kHz
SOURCE DEPTH: 42 METERS
RECEIVER DEPTH: 69 METERS
MAXIMUM RANGE: 37.5 kyd
NOISE LEVEL:
RECORDER NOT MEASURED
PAPER CHANGED
37.5 kyd
SOURCE INOPERATIVE
PROPAGATION LOSS, dB
40
60
80
100
120
140
ACOUSTIC RANGE, kyd
0
10
20
30
40

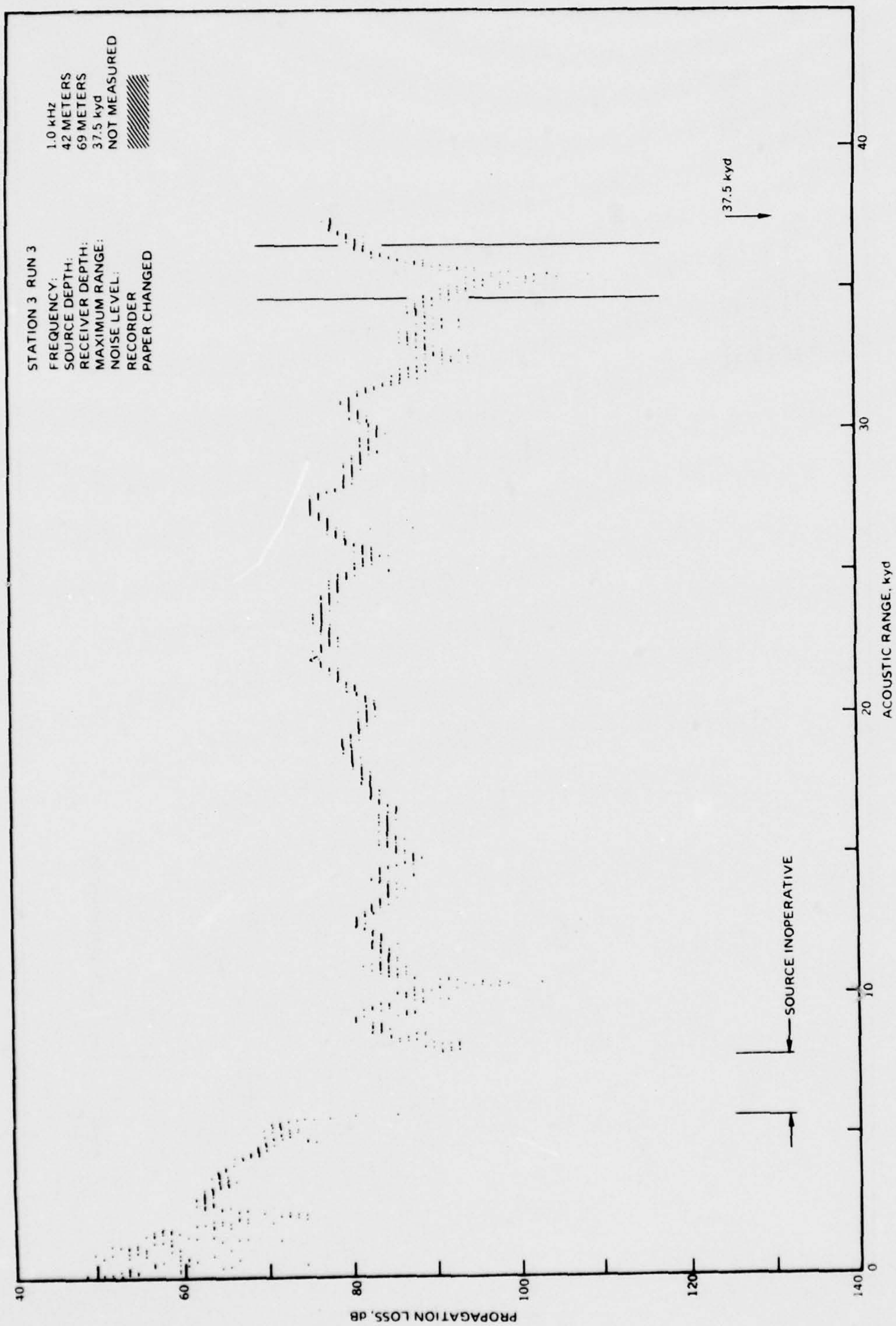

STATION 3 RUN 3
FREQUENCY: 0.4 kHz
SOURCE DEPTH: 42 METERS
RECEIVER DEPTH: 112 METERS
MAXIMUM RANGE: 37.5 kyd
NOISE LEVEL: 110 dB
RECORDER PAPER CHANGED
37.5 kyd
SOURCE INOPERATIVE
ACOUSTIC RANGE, kyd
PROPAGATION LOSS, dB
0
10
20
30
40
60
80
100
120
140

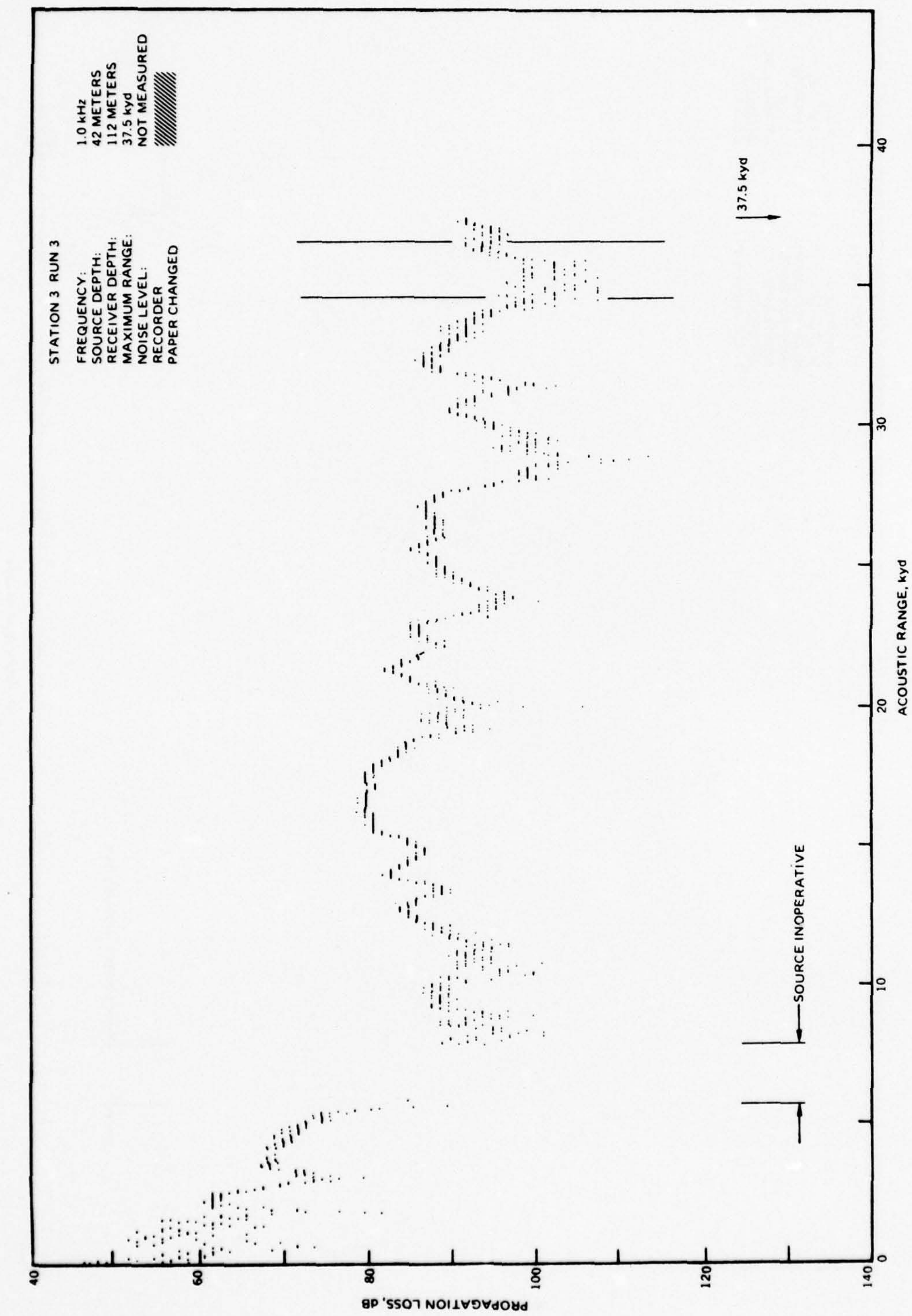


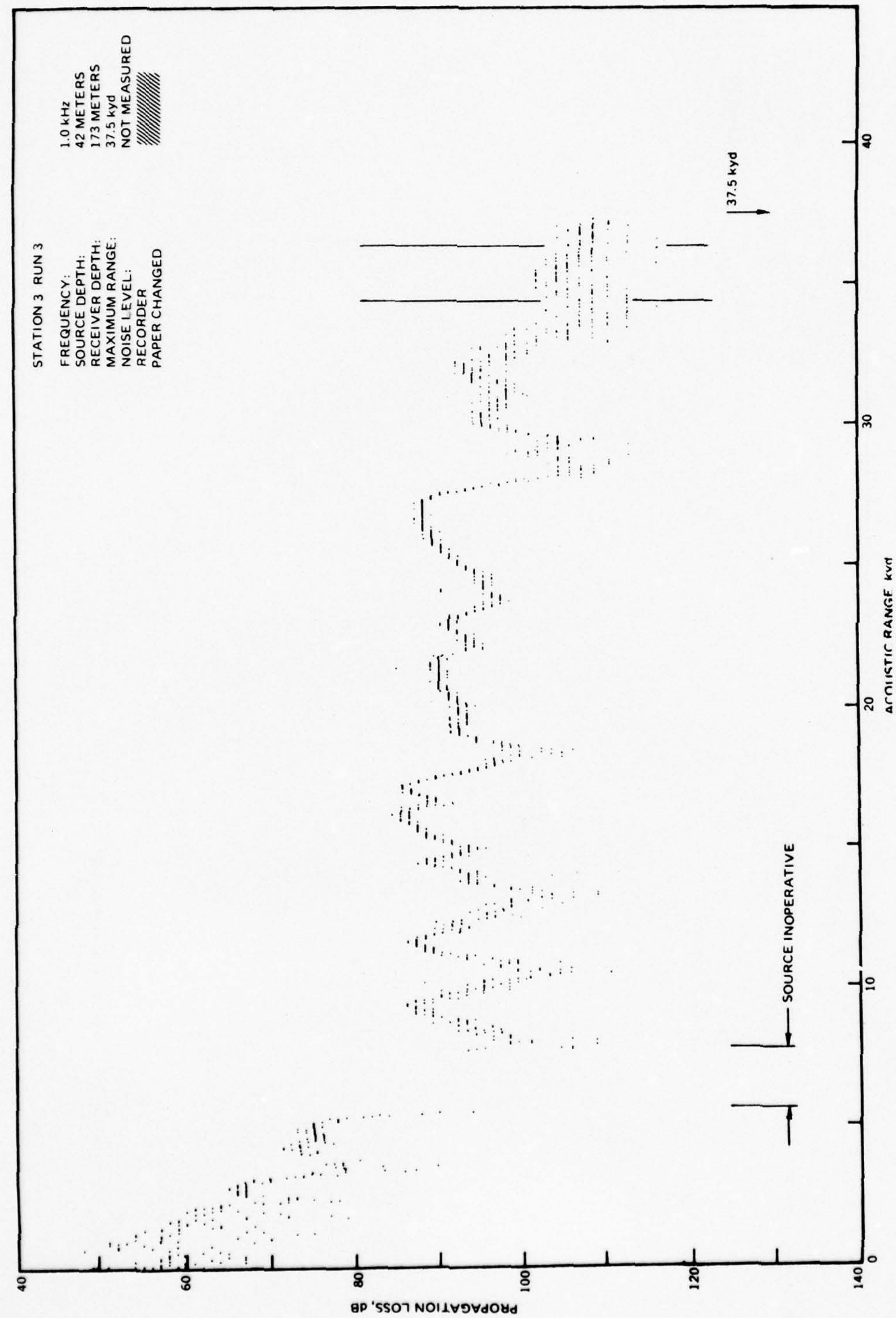
STATION 3 RUN 3
FREQUENCY: 0.4 kHz
SOURCE DEPTH: 42 METERS
RECEIVER DEPTH: 173 METERS
MAXIMUM RANGE: 37.5 kyd
NOISE LEVEL: 109-111 dB
RECORDER
PAPER CHANGED
37.5 kyd
SOURCE INOPERATIVE
PROPAGATION LOSS, dB
40
60
80
100
120
140
ACOUSTIC RANGE, kyd
0
10
20
30
40


STATION 3 RUN 3
FREQUENCY: 1.0 kHz
SOURCE DEPTH: 42 METERS
RECEIVER DEPTH: 6 METERS
MAXIMUM RANGE: 37.5 kyd
NOISE LEVEL: NOT MEASURED
RECORDER PAPER CHANGED
SOURCE INOPERATIVE
37.5 kyd
PROPAGATION LOSS, dB
40
60
80
100
120
140
ACOUSTIC RANGE, kyd
0
10
20
30
40


STATION 3 RUN 3
FREQUENCY: 1.0 kHz
SOURCE DEPTH: 42 METERS
RECEIVER DEPTH: 34 METERS
MAXIMUM RANGE: 37.5 kyd
NOISE LEVEL: 103 dB
RECORDER PAPER CHANGED
37.5 kyd
SOURCE INOPERATIVE
PROPAGATION LOSS, dB
40
60
80
100
120
140
ACOUSTIC RANGE, kyd
0
10
20
30
40


STATION 3 RUN 3
FREQUENCY: 1.0 kHz
SOURCE DEPTH: 42 METERS
RECEIVER DEPTH: 69 METERS
MAXIMUM RANGE: 37.5 kyd
NOISE LEVEL: NOT MEASURED
RECORDER PAPER CHANGED
37.5 kyd
SOURCE INOPERATIVE
PROPAGATION LOSS, dB
40
60
80
100
120
140
ACOUSTIC RANGE, kyd
0
10
20
30
40

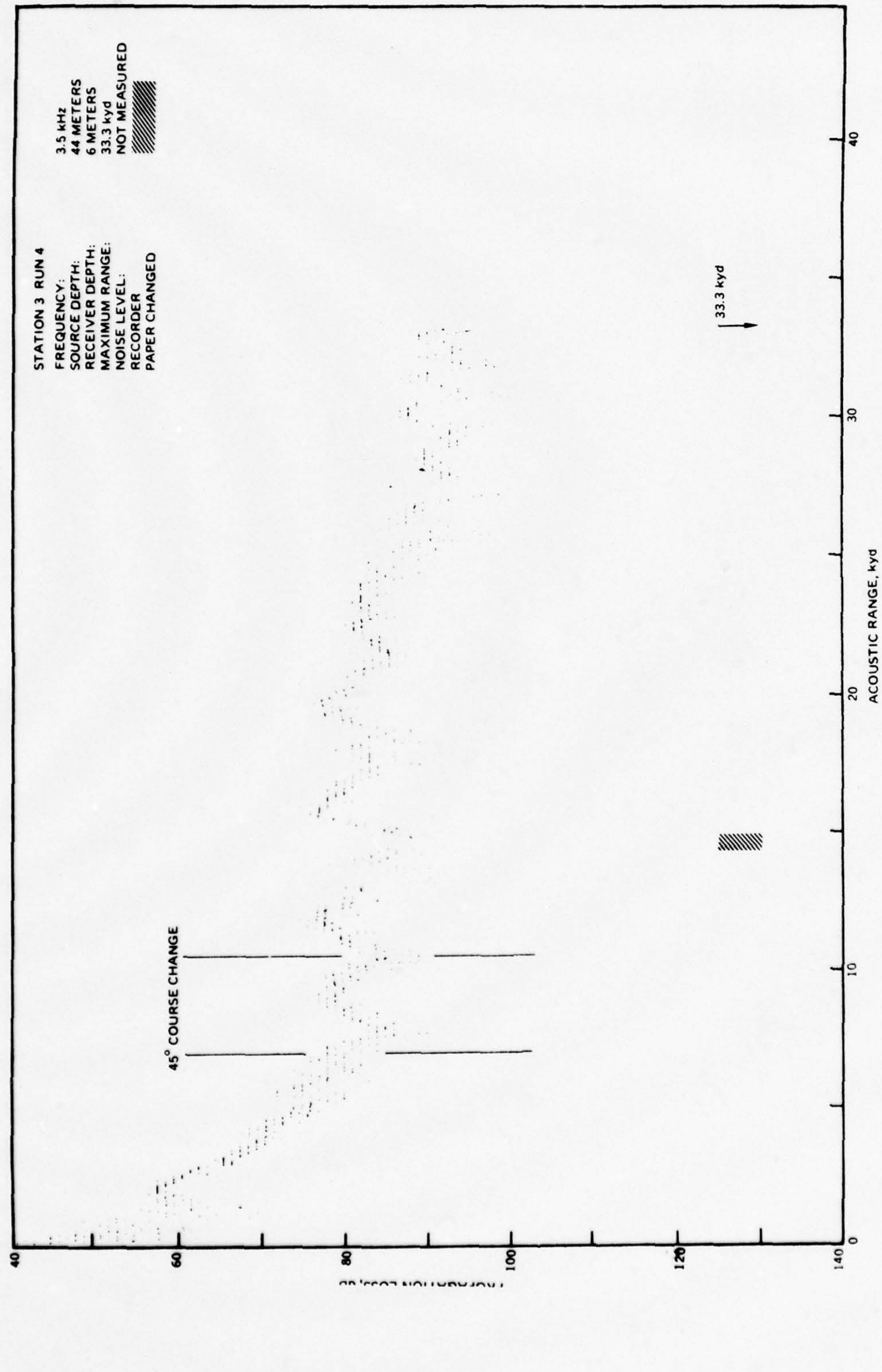

STATION 3 RUN 3
FREQUENCY: 1.0 kHz
SOURCE DEPTH: 42 METERS
RECEIVER DEPTH: 112 METERS
MAXIMUM RANGE: 37.5 kyd
NOISE LEVEL:
RECORDER NOT MEASURED
PAPER CHANGED
37.5 kyd
SOURCE INOPERATIVE
PROPAGATION LOSS, dB
40
60
80
100
120
140
ACOUSTIC RANGE, kyd
0
10
20
30
40


STATION 3 RUN 3
FREQUENCY: 1.0 kHz
SOURCE DEPTH: 42 METERS
RECEIVER DEPTH: 173 METERS
MAXIMUM RANGE: 37.5 kyd
NOISE LEVEL:
RECORDER PAPER CHANGED
NOT MEASURED
SOURCE INOPERATIVE
37.5 kyd
PROPAGATION LOSS, dB
40
60
80
100
120
140
0
10
20
30
40
ACOUSTIC RANGE, kyd

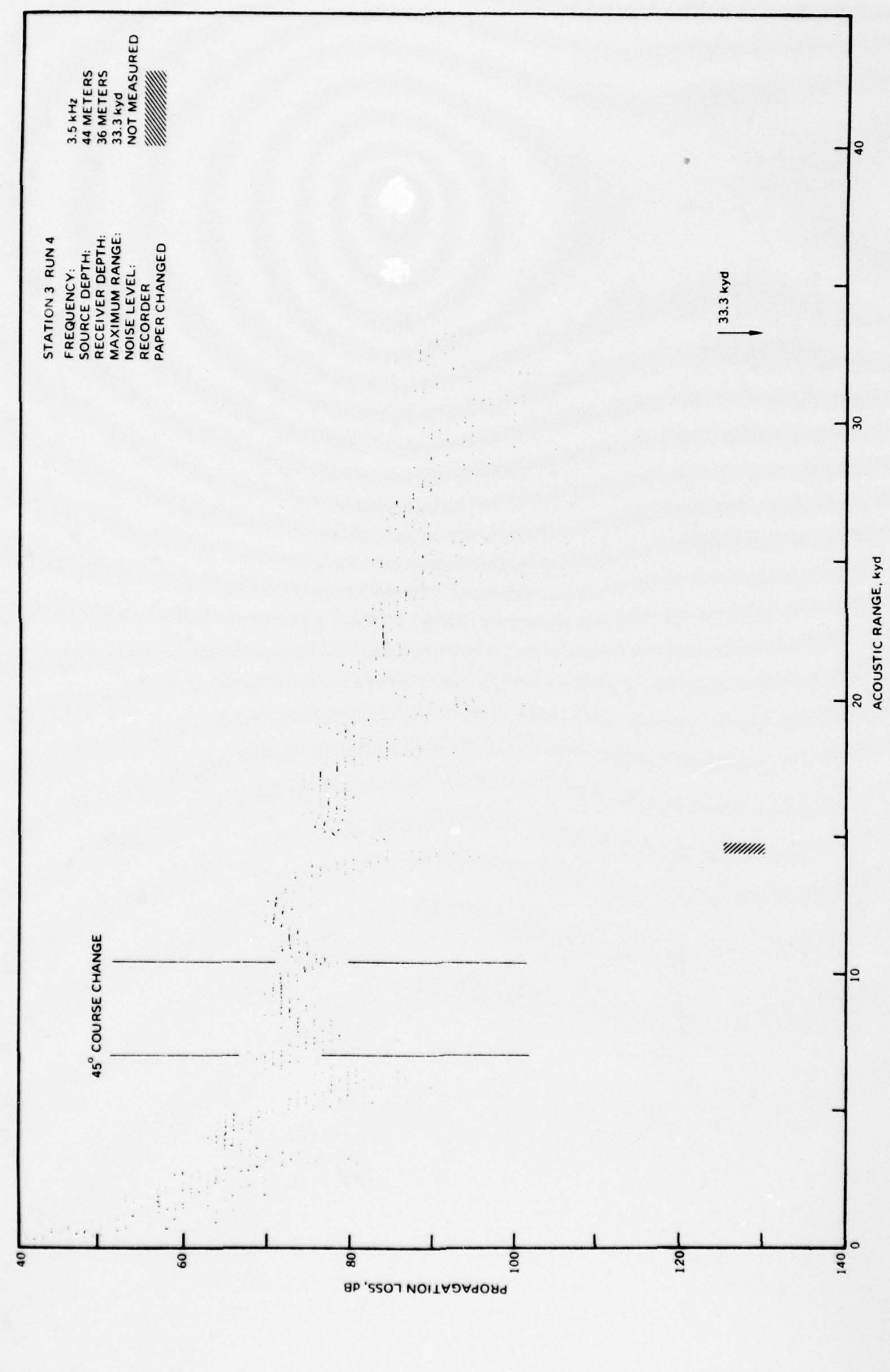
APPENDIX D

STATION 3 RUN 4

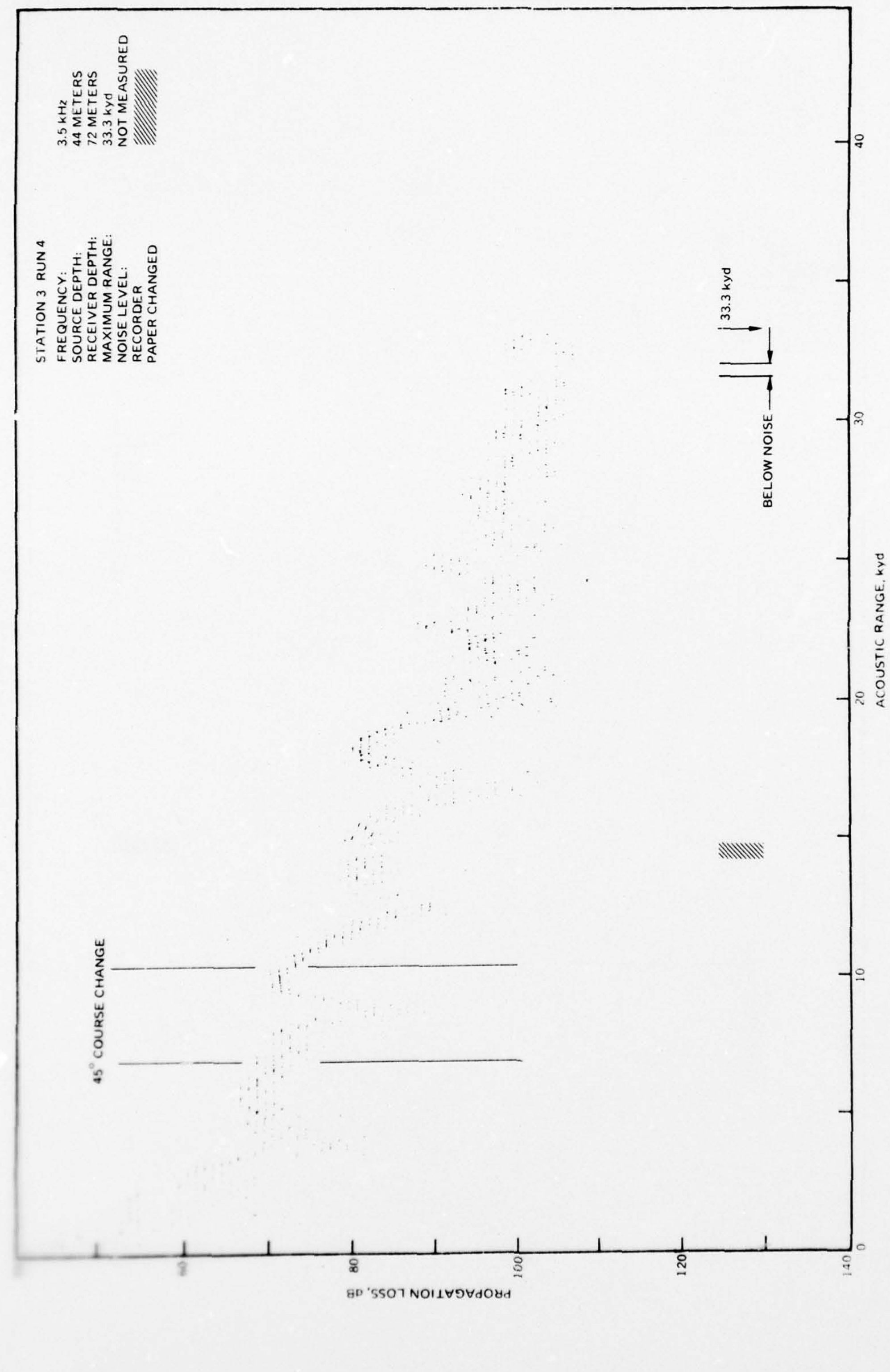
PROPAGATION LOSS VERSUS ACOUSTIC RANGE PLOTS

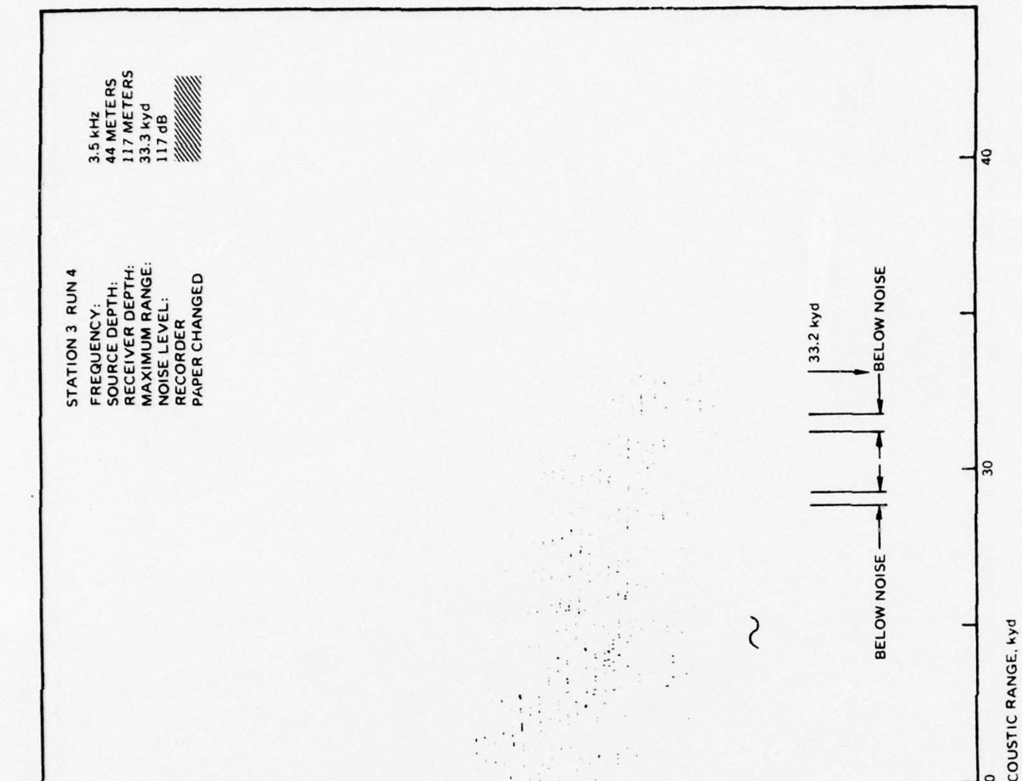


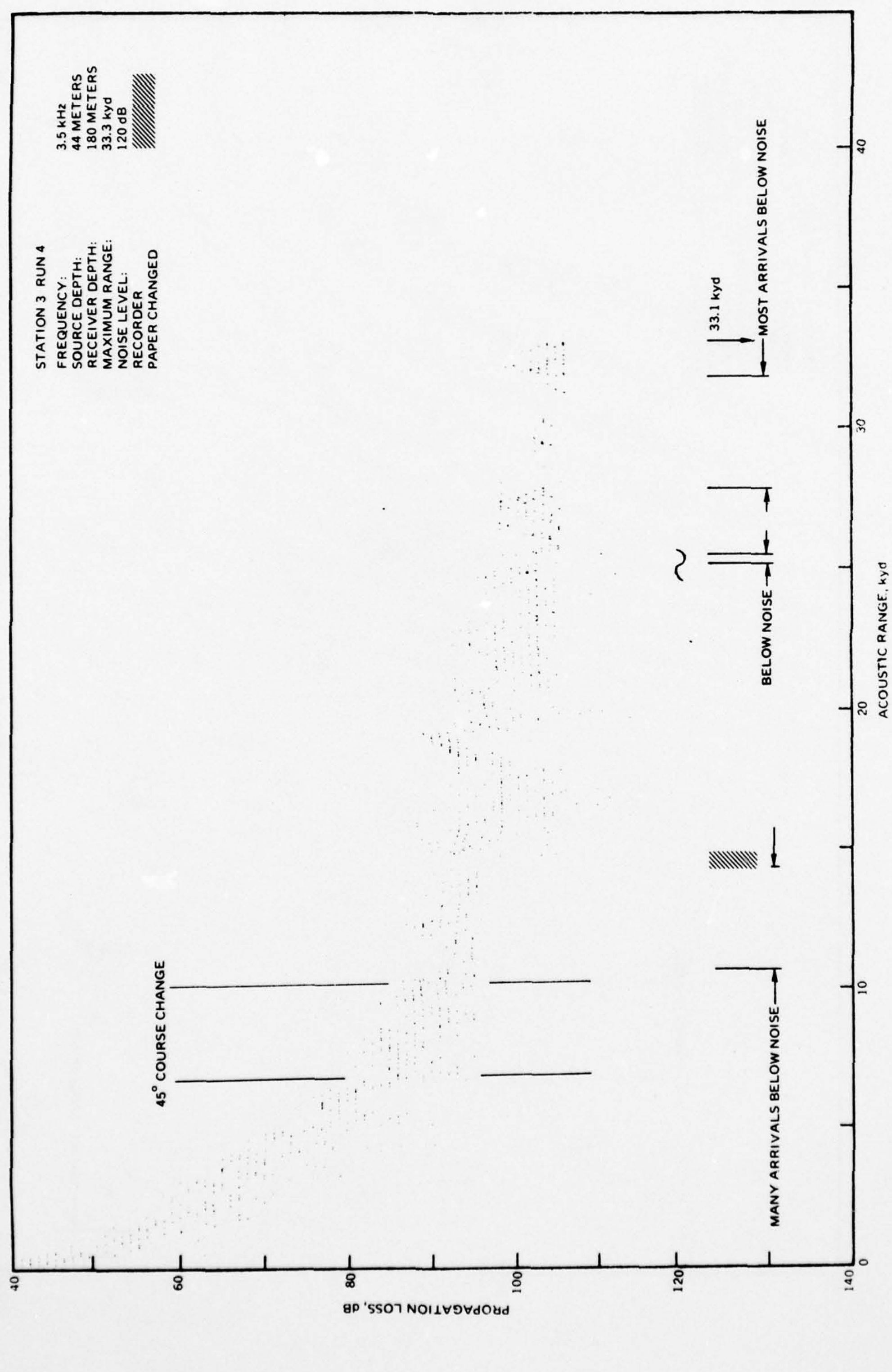
STATION 3 RUN 4
FREQUENCY: 3.5 kHz
SOURCE DEPTH: 44 METERS
RECEIVER DEPTH: 6 METERS
MAXIMUM RANGE: 33.3 kyd
NOISE LEVEL: NOT MEASURED
RECORDER
PAPER CHANGED
45° COURSE CHANGE
33.3 kyd
40
60
80
100
120
140
0
10
20
30
40
ACOUSTIC RANGE, kyd



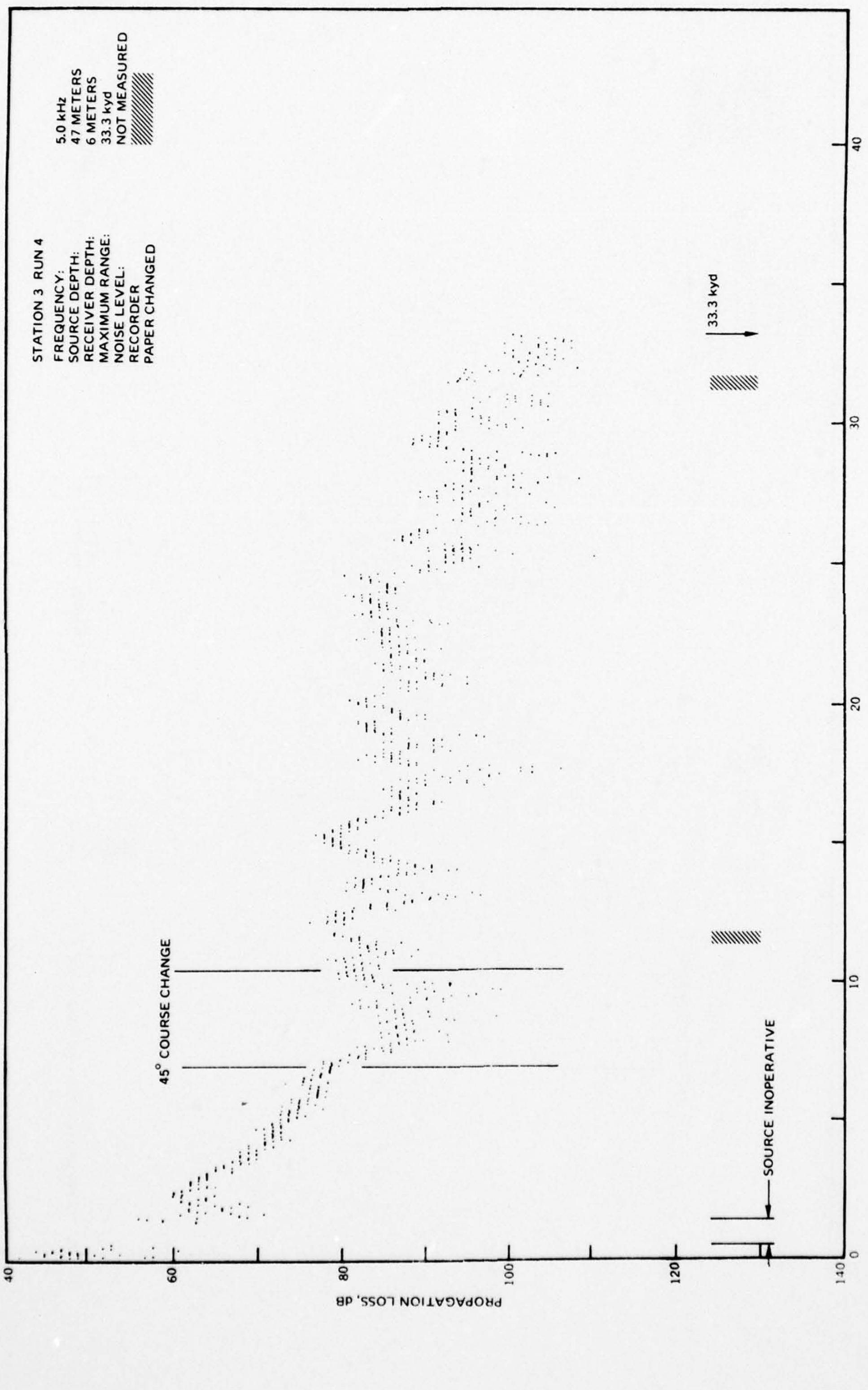
STATION 3 RUN 4
FREQUENCY: 3.5 kHz
SOURCE DEPTH: 44 METERS
RECEIVER DEPTH: 36 METERS
MAXIMUM RANGE: 33.3 kyd
NOISE LEVEL: NOT MEASURED
RECORDER PAPER CHANGED
45° COURSE CHANGE
33.3 kyd
PROPAGATION LOSS, dB
40
60
80
100
120
140
ACOUSTIC RANGE, kyd
0
10
20
30
40


STATION 3 RUN 4
FREQUENCY: 3.5 kHz
SOURCE DEPTH: 44 METERS
RECEIVER DEPTH: 72 METERS
MAXIMUM RANGE: 33.3 kyd
NOISE LEVEL:
RECORDER
PAPER CHANGED
NOT MEASURED
45° COURSE CHANGE
33.3 kyd
BELOW NOISE
PROPAGATION LOSS, dB
60
80
100
120
140
ACOUSTIC RANGE, kyd
0
10
20
30
40


STATION 3 RUN 4
FREQUENCY: 3.5 kHz
SOURCE DEPTH: 44 METERS
RECEIVER DEPTH: 117 METERS
MAXIMUM RANGE: 33.3 kyd
NOISE LEVEL: 117 dB
RECORDER PAPER CHANGED
45° COURSE CHANGE
33.2 kyd
BELOW NOISE
BELOW NOISE
PROPAGATION LOSS, dB
40
60
80
100
120
140
ACOUSTIC RANGE, kyd
0
10
20
30
40

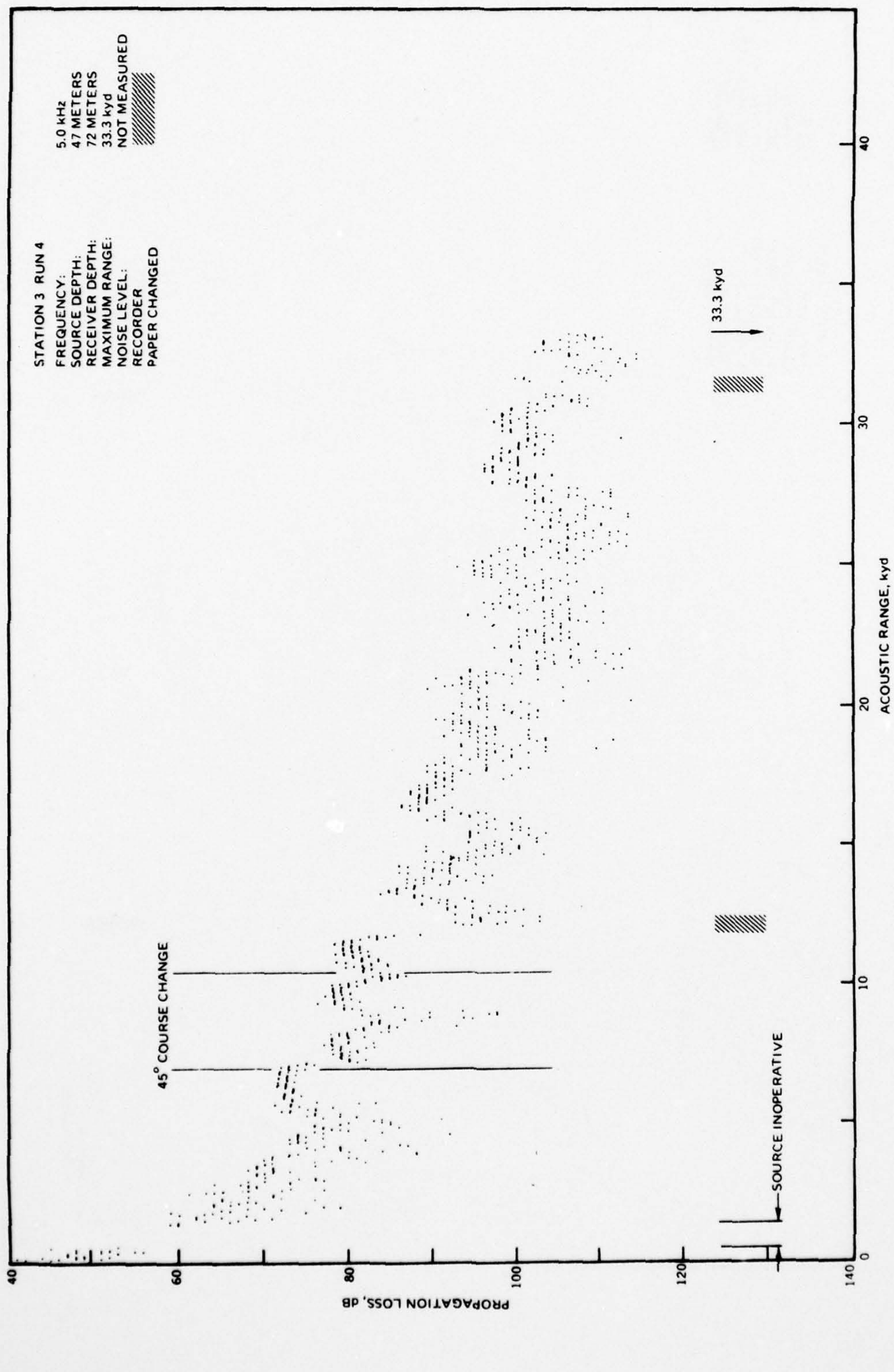


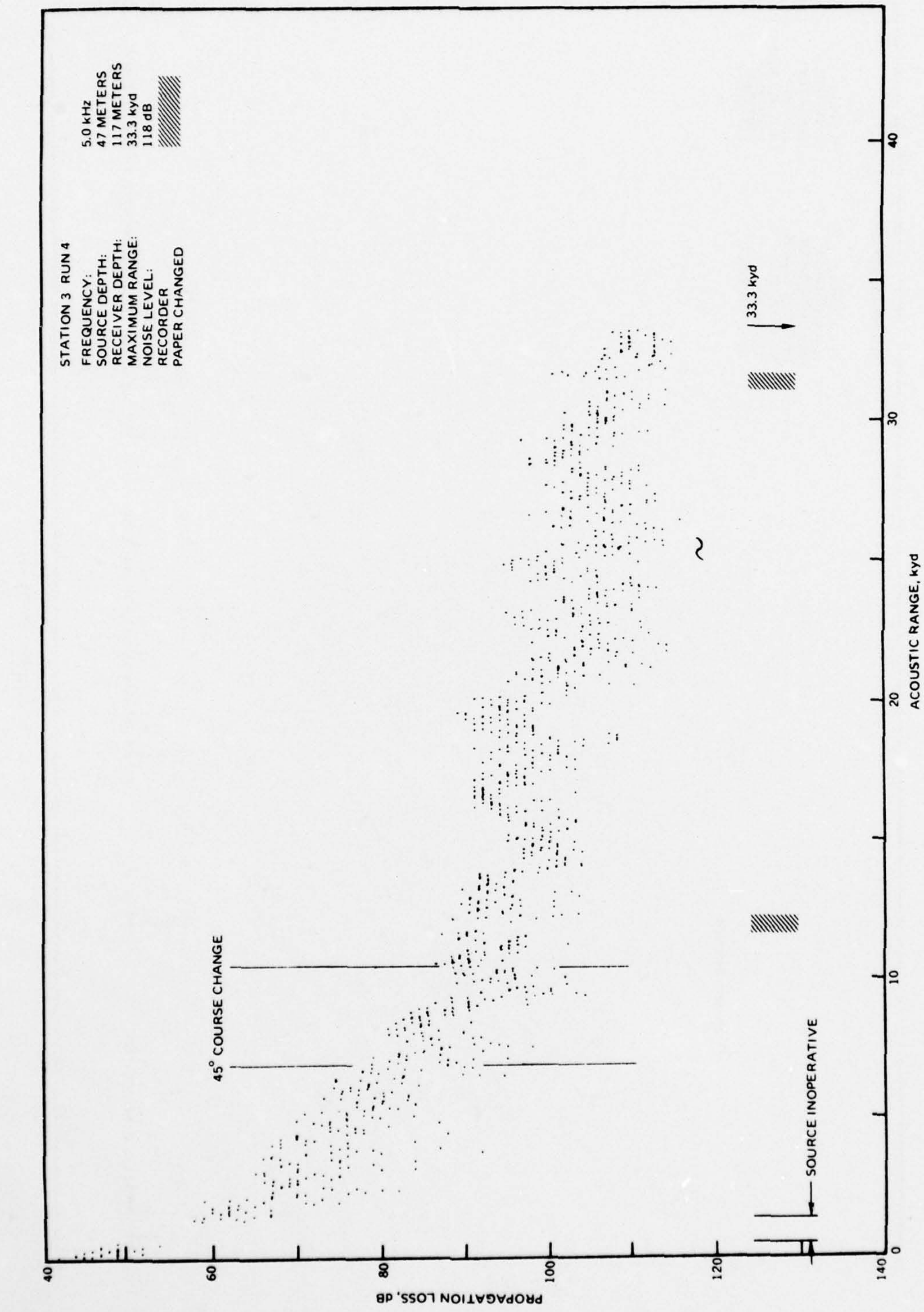
STATION 3 RUN 4
FREQUENCY: 3.5 kHz
SOURCE DEPTH: 44 METERS
RECEIVER DEPTH: 180 METERS
MAXIMUM RANGE: 33.3 kyd
NOISE LEVEL: 120 dB
RECORDER PAPER CHANGED
45° COURSE CHANGE
MANY ARRIVALS BELOW NOISE
BELOW NOISE
33.1 kyd
MOST ARRIVALS BELOW NOISE
PROPAGATION LOSS, dB
40
60
80
100
120
140
ACOUSTIC RANGE, kyd
0
10
20
30
40



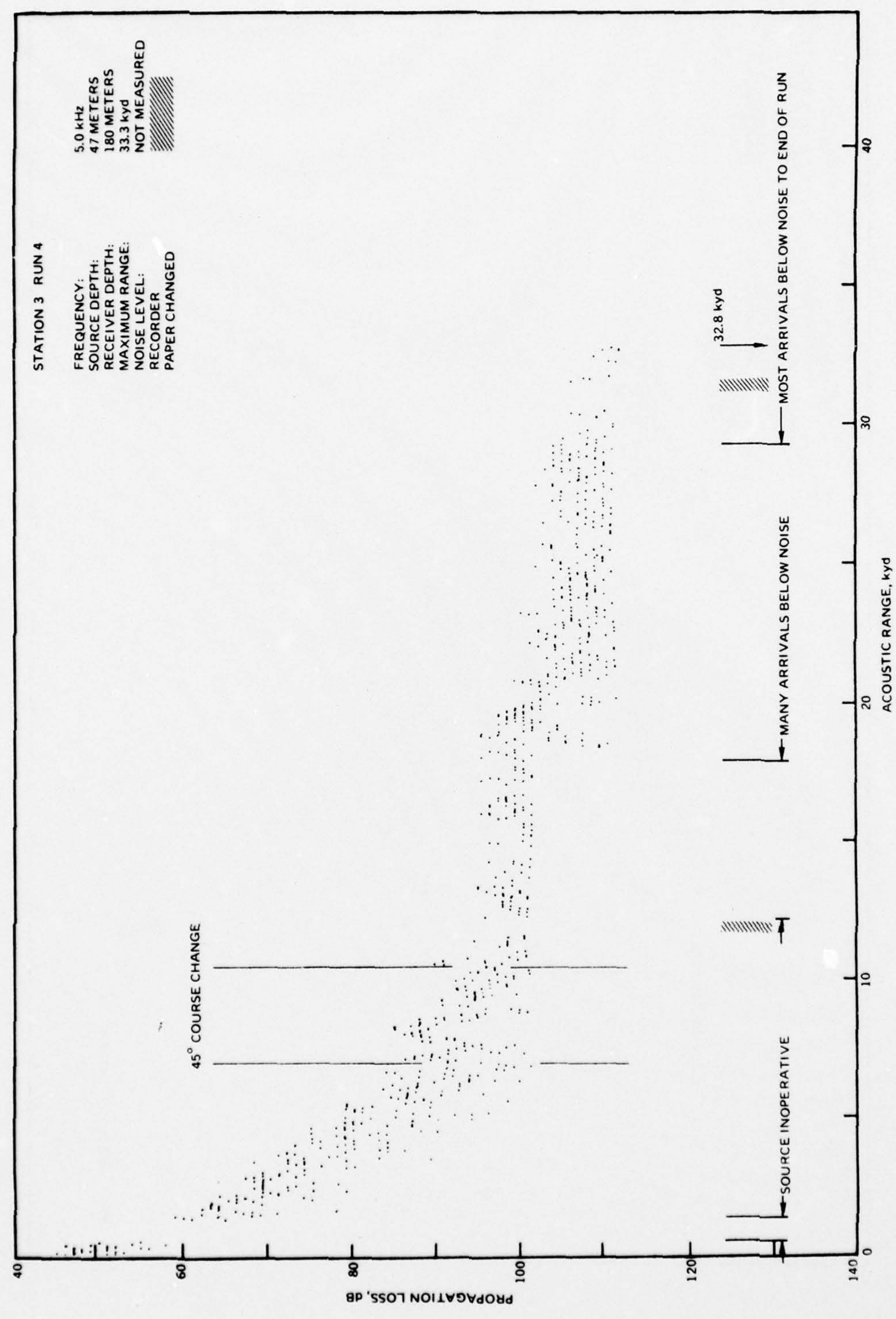
STATION 3 RUN 4
FREQUENCY: 5.0 kHz
SOURCE DEPTH: 47 METERS
RECEIVER DEPTH: 6 METERS
MAXIMUM RANGE: 33.3 kyd
NOISE LEVEL: NOT MEASURED
RECORDER PAPER CHANGED
45° COURSE CHANGE
SOURCE INOPERATIVE
33.3 kyd
PROPAGATION LOSS, dB
ACOUSTIC RANGE, kyd
40
60
80
100
120
140
0
10
20
30
40


STATION 3 RUN 4
FREQUENCY: 5.0 kHz
SOURCE DEPTH: 47 METERS
RECEIVER DEPTH: 36 METERS
MAXIMUM RANGE: 33.3 kyd
NOISE LEVEL: NOT MEASURED
RECORDER PAPER CHANGED
45° COURSE CHANGE
SOURCE INOPERATIVE
33.3 kyd
PROPAGATION LOSS, dB
40
60
80
100
120
140
ACOUSTIC RANGE, kyd
0
10
20
30
40


STATION 3 RUN 4
FREQUENCY: 5.0 kHz
SOURCE DEPTH: 47 METERS
RECEIVER DEPTH: 72 METERS
MAXIMUM RANGE: 33.3 kyd
NOISE LEVEL: NOT MEASURED
RECORDER PAPER CHANGED
45° COURSE CHANGE
SOURCE INOPERATIVE
33.3 kyd
PROPAGATION LOSS, dB
40
60
80
100
120
140
ACOUSTIC RANGE, kyd
0
10
20
30
40



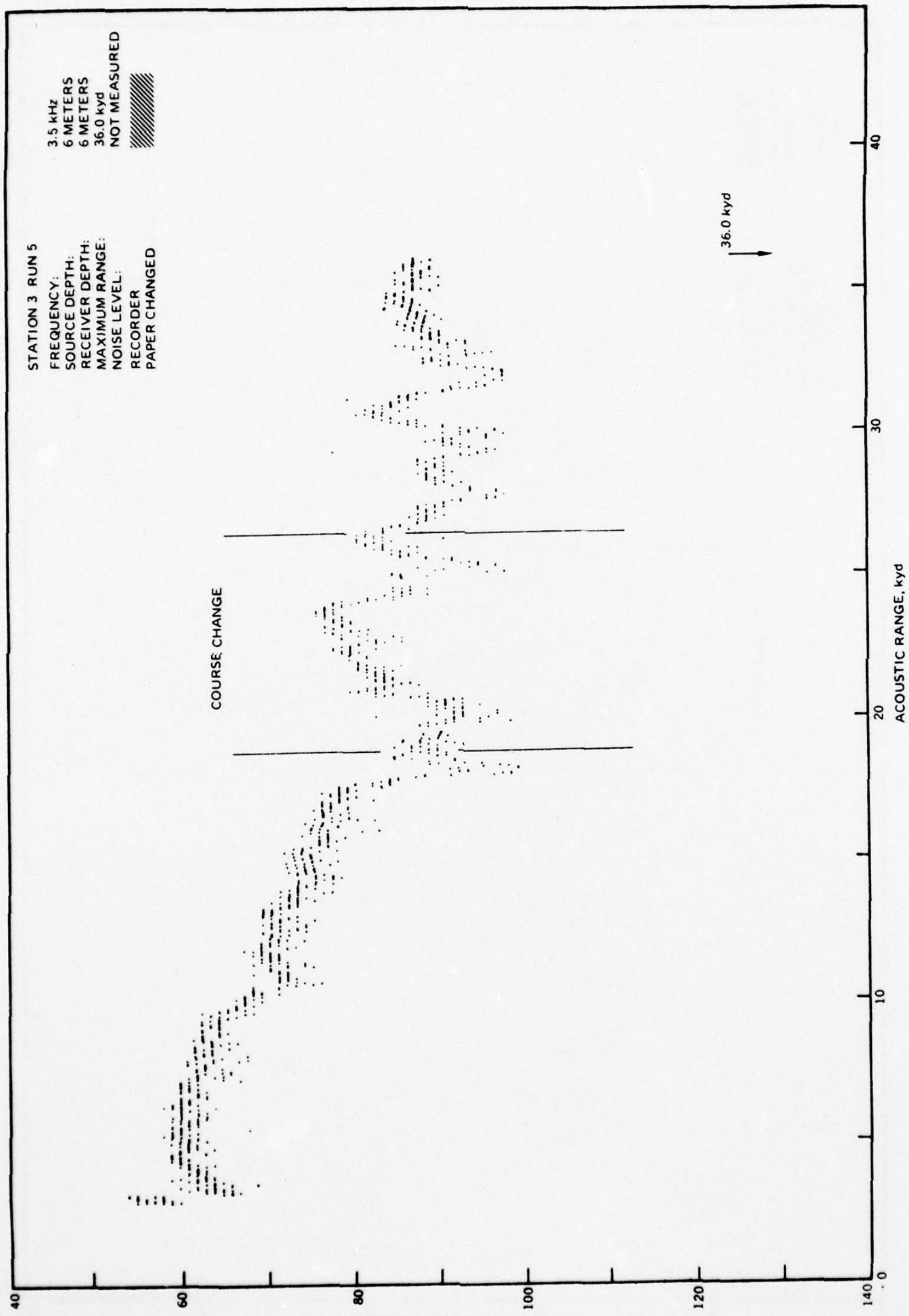
STATION 3 RUN 4
FREQUENCY: 5.0 kHz
SOURCE DEPTH: 47 METERS
RECEIVER DEPTH: 117 METERS
MAXIMUM RANGE: 33.3 kyd
NOISE LEVEL: 118 dB
RECORDER PAPER CHANGED
45° COURSE CHANGE
SOURCE INOPERATIVE
33.3 kyd
PROPAGATION LOSS, dB
ACOUSTIC RANGE, kyd
40
60
80
100
120
140
0
10
20
30
40

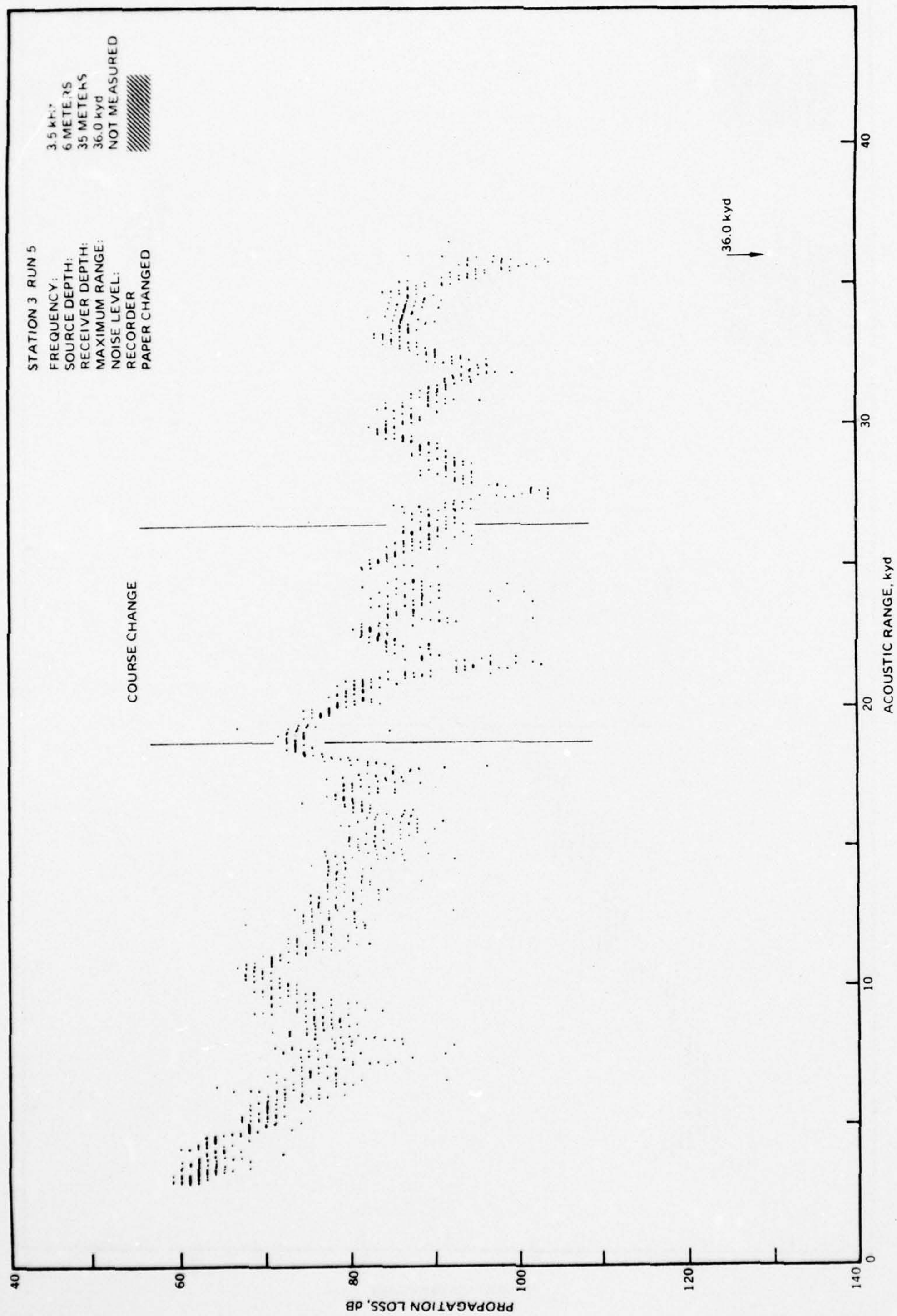

STATION 3 RUN 4
FREQUENCY: 5.0 kHz
SOURCE DEPTH: 47 METERS
RECEIVER DEPTH: 180 METERS
MAXIMUM RANGE: 33.3 kyd
NOISE LEVEL: NOT MEASURED
RECORDER PAPER CHANGED
45° COURSE CHANGE
SOURCE INOPERATIVE
MANY ARRIVALS BELOW NOISE
MOST ARRIVALS BELOW NOISE TO END OF RUN
32.8 kyd
PROPAGATION LOSS, dB
40
60
80
100
120
140
0
10
20
30
40
ACOUSTIC RANGE, kyd

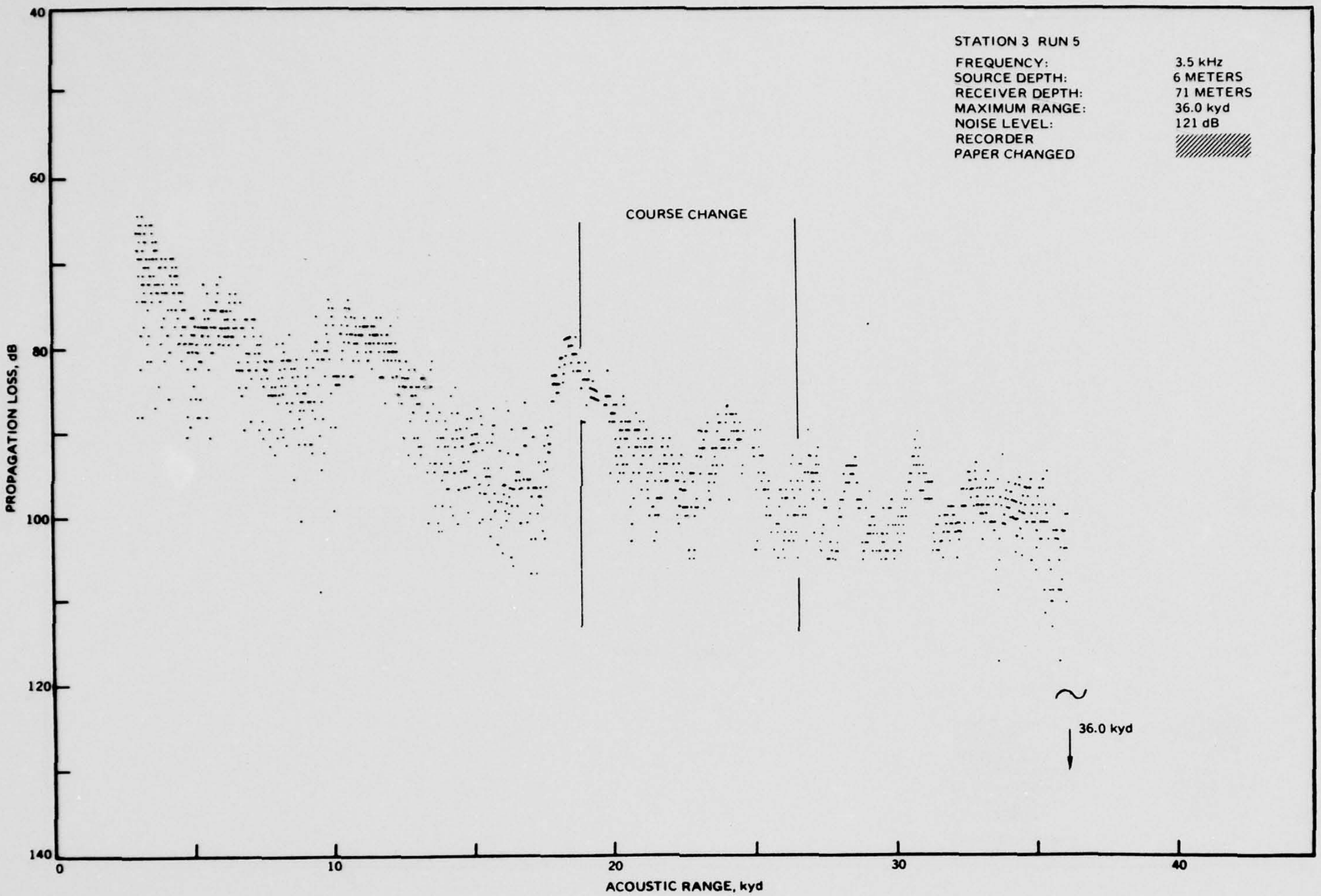
APPENDIX E

STATION 3 RUN 5

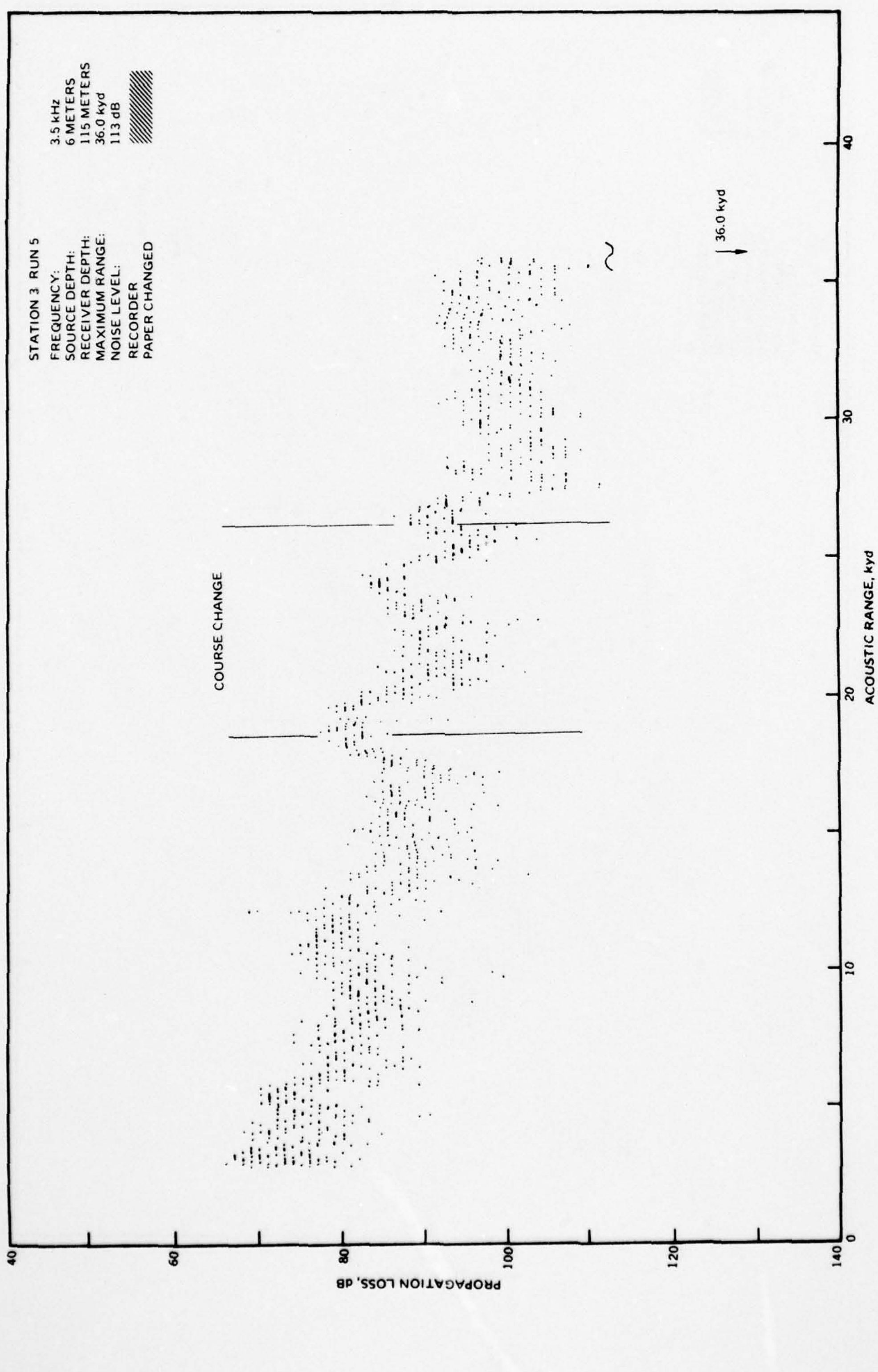
PROPAGATION LOSS VERSUS ACOUSTIC RANGE PLOTS

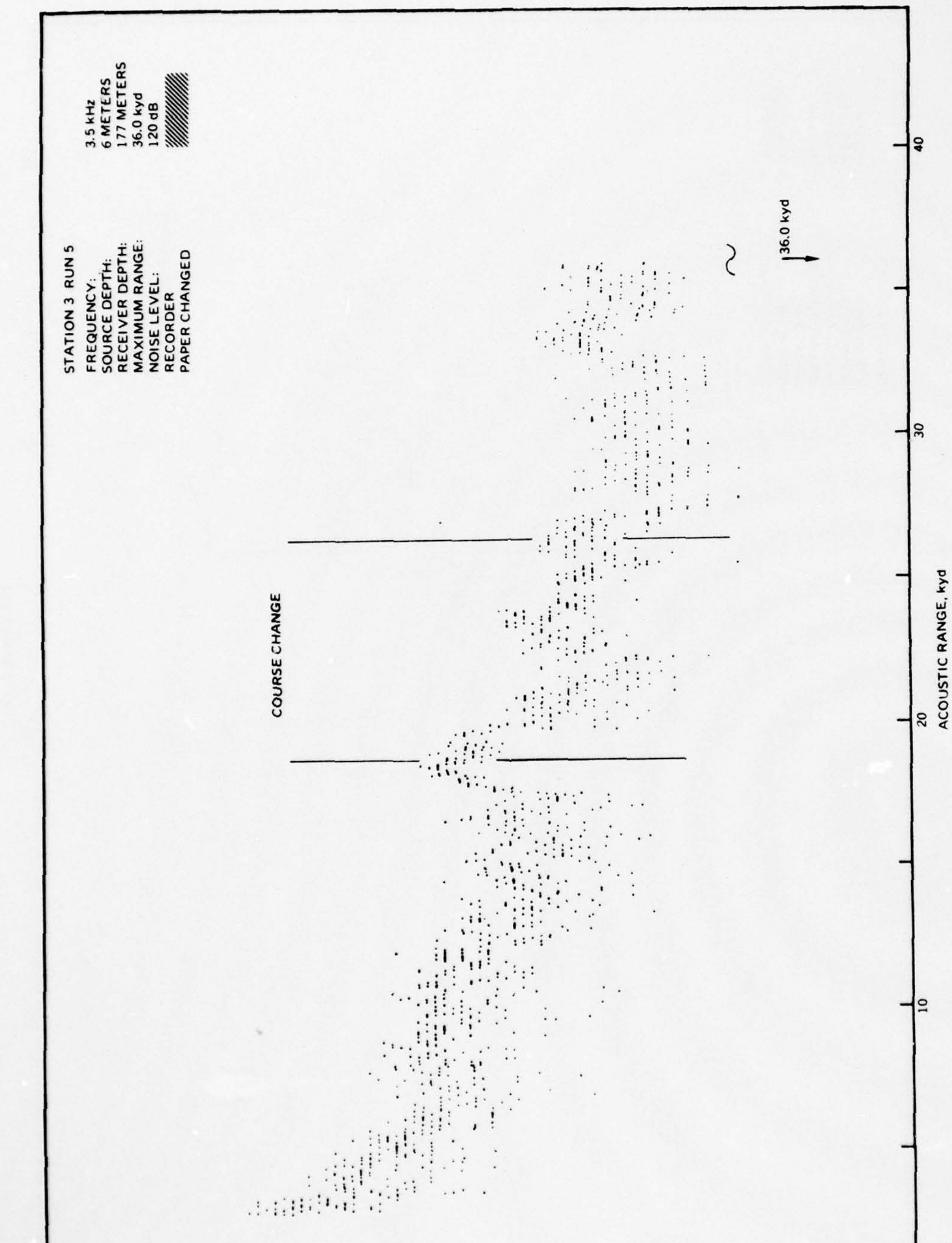

STATION 3 RUN 5
FREQUENCY: 3.5 kHz
SOURCE DEPTH: 6 METERS
RECEIVER DEPTH: 6 METERS
MAXIMUM RANGE: 36.0 kyd
NOISE LEVEL: NOT MEASURED
RECORDER PAPER CHANGED
COURSE CHANGE
36.0 kyd
PROPAGATION LOSS, dB
40
60
80
100
120
140
ACOUSTIC RANGE, kyd
0
10
20
30
40


STATION 3 RUN 5
FREQUENCY:
SOURCE DEPTH:
RECEIVER DEPTH:
MAXIMUM RANGE:
NOISE LEVEL:
RECORDER
PAPER CHANGED
6 METERS
35 METERS
36.0 kyd
NOT MEASURED
COURSE CHANGE
36.0 kyd
PROPAGATION LOSS, dB
ACOUSTIC RANGE, kyd
40
60
80
100
120
140
0
10
20
30
40



STATION 3 RUN 5
FREQUENCY: 3.5 kHz
SOURCE DEPTH: 6 METERS
RECEIVER DEPTH: 71 METERS
MAXIMUM RANGE: 36.0 kyd
NOISE LEVEL: 121 dB
RECORDER PAPER CHANGED
COURSE CHANGE
36.0 kyd
PROPAGATION LOSS, dB
40
60
80
100
120
140
ACOUSTIC RANGE, kyd
0
10
20
30
40


STATION 3 RUN 5
FREQUENCY: 3.5 kHz
SOURCE DEPTH: 6 METERS
RECEIVER DEPTH: 115 METERS
MAXIMUM RANGE: 36.0 kyd
NOISE LEVEL: 113 dB
RECORDER PAPER CHANGED
COURSE CHANGE
36.0 kyd
PROPAGATION LOSS, dB
40
60
80
100
120
140
ACOUSTIC RANGE, kyd
0
10
20
30
40



STATION 3 RUN 5
FREQUENCY: 3.5 kHz
SOURCE DEPTH: 6 METERS
RECEIVER DEPTH: 177 METERS
MAXIMUM RANGE: 36.0 kyd
NOISE LEVEL: 120 dB
RECORDER PAPER CHANGED
COURSE CHANGE
36.0 kyd
PROPAGATION LOSS, dB
40
60
80
100
120
140
ACOUSTIC RANGE, kyd
0
10
20
30
40

AD-A049 081   NAVAL UNDERSEA CENTER SAN DIEGO CALIF   F/G 20/1
SURFACE-DUCT SONAR MEASUREMENTS (SUDS I - 1972) PROPAGATION LOS--ETC(U)
APR 76 E R ANDERSON

UNCLASSIFIED   NUC-TP-464-VOL-4   NL

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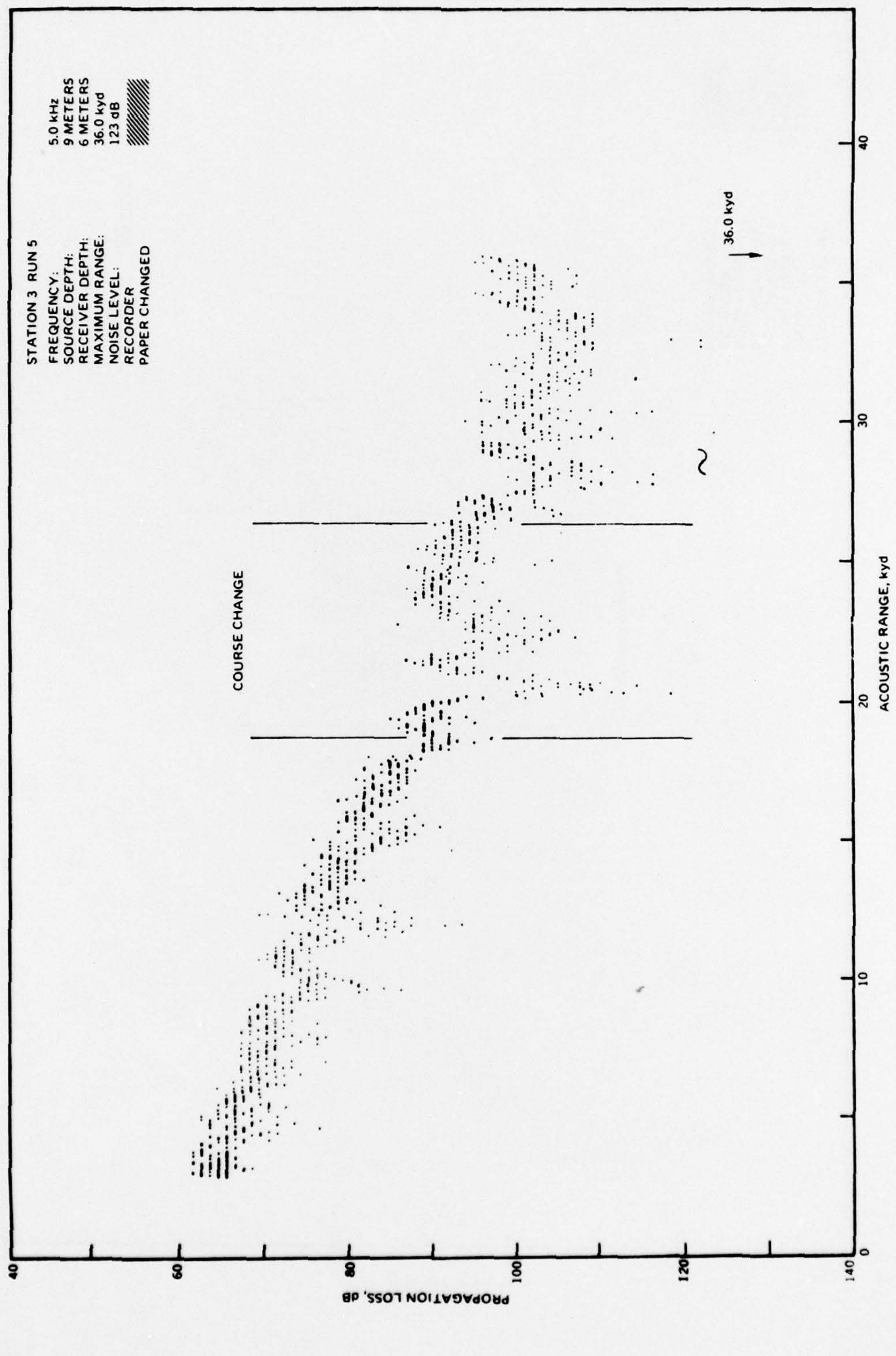
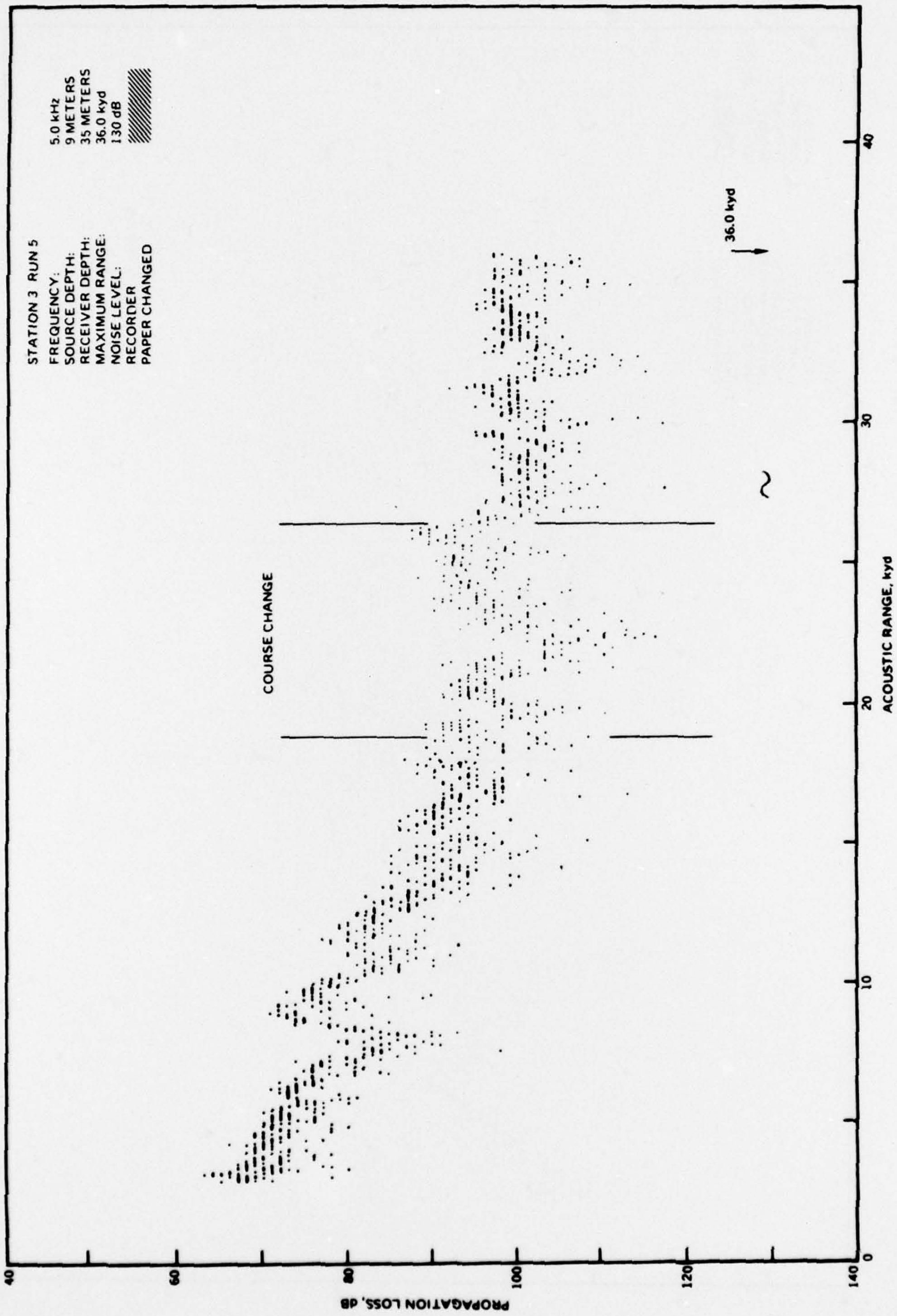
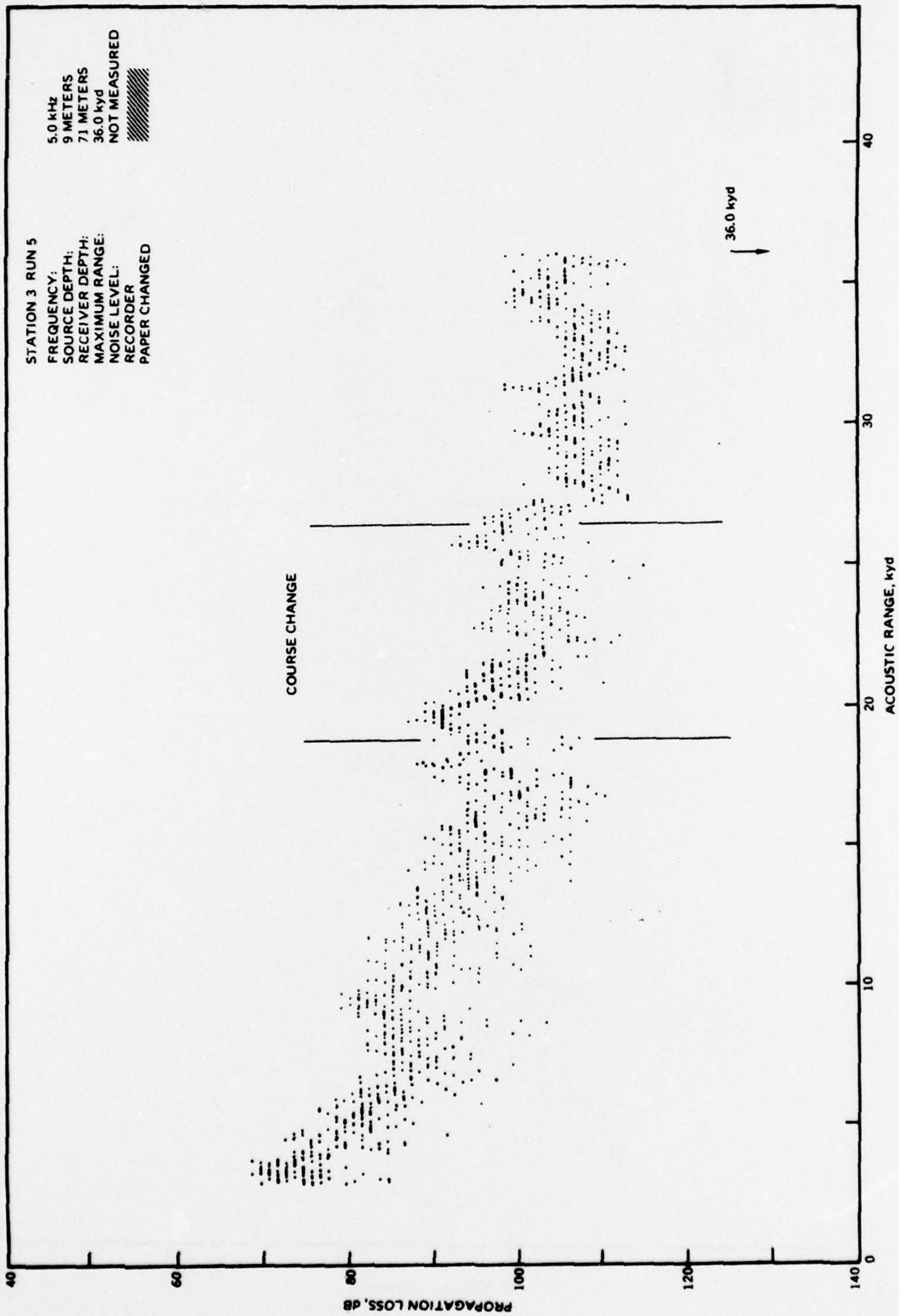
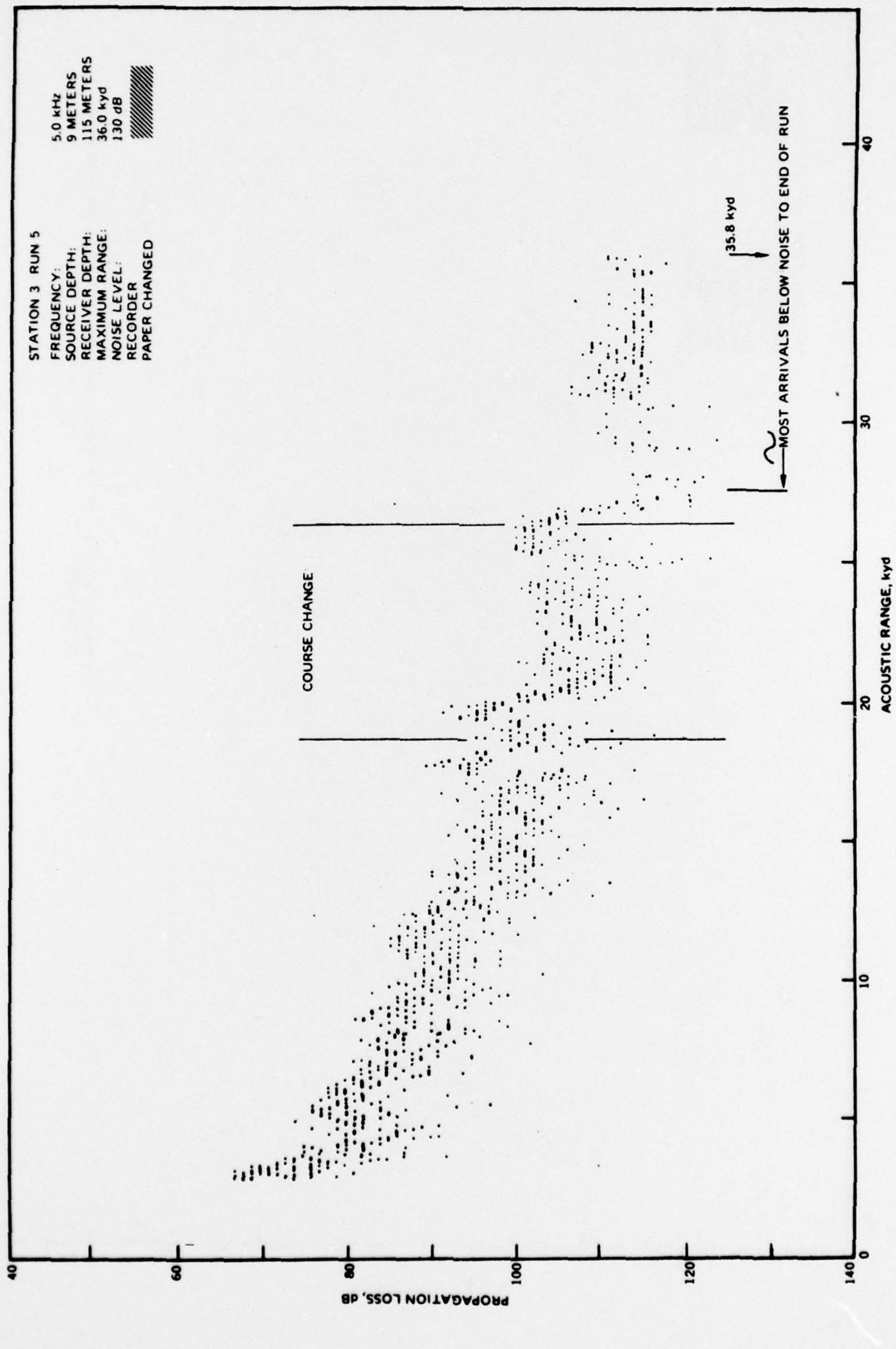
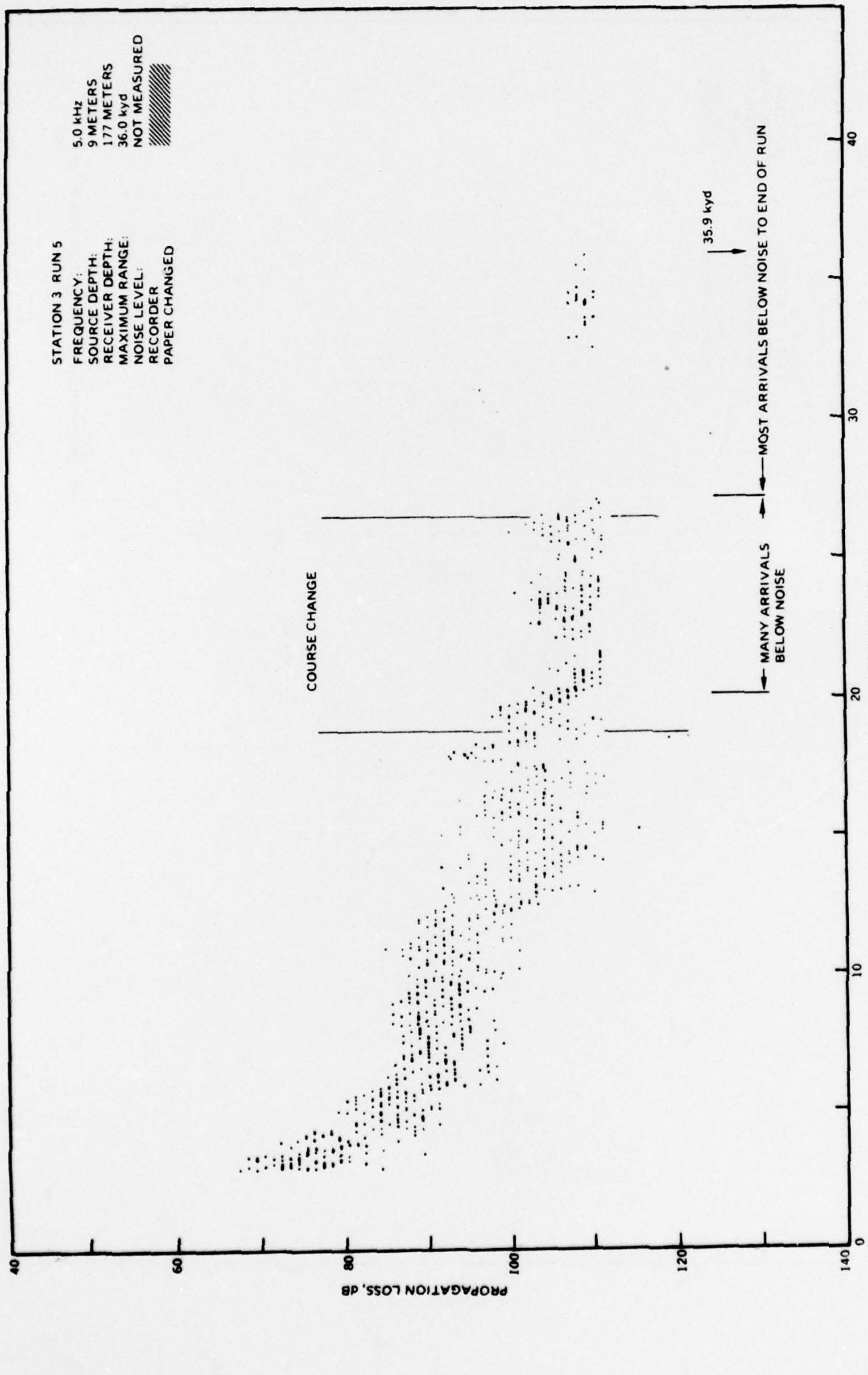

STATION 3 RUN 5
FREQUENCY: 5.0 kHz
SOURCE DEPTH: 9 METERS
RECEIVER DEPTH: 6 METERS
MAXIMUM RANGE: 36.0 kyd
NOISE LEVEL: 123 dB
RECORDER
PAPER CHANGED
COURSE CHANGE
36.0 kyd
PROPAGATION LOSS, dB
40
60
80
100
120
140
ACOUSTIC RANGE, kyd
0
10
20
30
40


STATION 3 RUN 5
FREQUENCY: 5.0 kHz
SOURCE DEPTH: 9 METERS
RECEIVER DEPTH: 35 METERS
MAXIMUM RANGE: 36.0 kyd
NOISE LEVEL: 130 dB
RECORDER
PAPER CHANGED
COURSE CHANGE
36.0 kyd
PROPAGATION LOSS, dB
40
60
80
100
120
140
ACOUSTIC RANGE, kyd
0
10
20
30
40


STATION 3 RUN 5
FREQUENCY: 5.0 kHz
SOURCE DEPTH: 9 METERS
RECEIVER DEPTH: 71 METERS
MAXIMUM RANGE: 36.0 kyd
NOISE LEVEL: NOT MEASURED
RECORDER
PAPER CHANGED
COURSE CHANGE
36.0 kyd
PROPAGATION LOSS, dB
40
60
80
100
120
140
ACOUSTIC RANGE, kyd
0
10
20
30
40


STATION 3 RUN 5
FREQUENCY: 5.0 kHz
SOURCE DEPTH: 9 METERS
RECEIVER DEPTH: 115 METERS
MAXIMUM RANGE: 36.0 kyd
NOISE LEVEL: 130 dB
RECORDER PAPER CHANGED
COURSE CHANGE
35.8 kyd
MOST ARRIVALS BELOW NOISE TO END OF RUN
ACOUSTIC RANGE, kyd
0
10
20
30
40
PROPAGATION LOSS, dB
40
60
80
100
120
140


STATION 3 RUN 5
FREQUENCY: 5.0 kHz
SOURCE DEPTH: 9 METERS
RECEIVER DEPTH: 177 METERS
MAXIMUM RANGE: 36.0 kyd
NOISE LEVEL: NOT MEASURED
RECORDER
PAPER CHANGED
COURSE CHANGE
35.9 kyd
MANY ARRIVALS BELOW NOISE
MOST ARRIVALS BELOW NOISE TO END OF RUN
PROPAGATION LOSS, dB
ACOUSTIC RANGE, kyd
40
60
80
100
120
140
0
10
20
30
40